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The Drone Perspective - A research project exploring the advancement of the commercial drone industry and its effect on society.

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**ABSTRACT**

This project explores the relationship between technological growth and the impact of drones. We did this by analyzing the interdependencies of drone capability, public opinion, and regulation as they guide the growth of the drone industry in wide variety of applications. Technological growth increases the usefulness of drones in all applications. Public opinion and regulation prevent drones from being realized at their full potential, for fear of misuse.

https://thedroneperspective.wordpress.com/
# Table of Contents

**Executive Summary** .................................................................................................................. 3

**Technology** .............................................................................................................................. 8  
  Rogue Drone – Loose in the Amazon ......................................................................................... 8  
  How can we make drones safer and more reliable – Is it Technology? ................................. 13  
  Drone Proofing Airlines? ............................................................................................................... 19  
  Can We Stop Drones with Drones? ........................................................................................... 24  
  The Next Generation of Drones: Engines!?!? ........................................................................... 28  

**Applications** ............................................................................................................................. 33  
  Drones for Every Species ............................................................................................................ 33  
  Mapping the Way of the World .................................................................................................. 38  
  Drones: The new Steadicam ........................................................................................................ 41  
  An Agricultural Bloom ................................................................................................................. 44  
  Construction, Automation, Satisfaction ....................................................................................... 48  
  Drones in the Pursuit of Saving Lives ......................................................................................... 51  

**Regulations** ............................................................................................................................... 55  
  Model Aircraft: A New Era of Legal Debate ............................................................................. 55  
  Drones and Your Privacy ............................................................................................................. 59  
  Model Aircraft: What to Know .................................................................................................... 65  
  Public Aircraft Operations .......................................................................................................... 69  
  The Likely Future of Commercial Drone Regulation ................................................................ 73  
  Praise and Criticism for the FAA ............................................................................................... 81  

**Viewpoints** ............................................................................................................................... 86  
  A Community Decision: How Drone Use will Expand U.S. Farming ...................................... 86  
  Eliminating the Stigma ............................................................................................................... 95  
  Dreaming Ahead ......................................................................................................................... 98  

**Appendix** ................................................................................................................................ 101  
  Acknowledgement and Interviews ............................................................................................. 101  
  Presentation Script ....................................................................................................................... 104
Executive Summary

The Drone Perspective is a research project conducted by five juniors from Worcester Polytechnic Institute for the Interactive Qualifying Project. This project explores the interaction between the regulation, technology, applications and public opinion in driving the commercial drone industry. The objective was to study how the growth in technology provided opportunities for innovative applications to emerge and how regulations and public opinion in the United States concerning drones influenced the success of these applications. The inter-dependencies of these factors determine the growth of the drone industry in addition to providing a range of tools for the society to perform tasks more efficiently.

We conducted 15 interviews with a range of drone experts in the U.S., each of which specialized in a particular area of the drone industry. The opinions, experiences, and knowledge these lawyers, Unmanned Aerial Vehicle (UAV) pilots, and manufactures shared, helped us evaluate the current and likely future of drone usage as well as anti-drone technology. We coupled the opinions we learned from our interviews with facts, developments, and anecdotes to identify the advantages, and shortcomings of technology, regulation, public opinion in various applications.
The info-graphic visualizes the relationship between technological advancement and a drone’s impact on society. In the most direct sense, advances in technology will give drones more tools to operate. However, the utilization of these tools depends highly on regulation and public opinion. Because public opinion varies by where the drones are being used, how they are used, by whom and regulation, we divided the operational ability of drones into four different categories: Prototype, Assess, Address, and Automation-Artificial Intelligence. Each category represents a more complex level of operation. The Prototype category, represents the establishment of a platform. Individuals and companies experimenting with fixed-wing or multi-copter drones for use in new applications fall into this category. The Assessment category means that drones are being used to collect data, using sensors attached to the platform. Drones taking pictures, generating 3-d maps, or thermal imagery fall into this category. Address means that a physical task is completed by the flying platform. A drone that collects soil samples, sprays pesticides, or delivers packages falls into this category. Automation-Artificial Intelligence is a largely futuristic category where a drone platform processes the information collected by its sensors to make decisions (without human intervention) and address issues on its own. Technology pushes the
individual growth of these categories, and as they grow, new hardware is developed. The hardware allows drones to have greater potential, but this potential cannot be realized until the government and the public is on board.

Even during the relatively short time over which this project took place, drone technologies have been rapidly advancing from the Lily Drone that will follow you wherever you go to Snotbots that help to study whales. Many of these innovations have been made for drone platforms. Quadcopters, for example, are great for beginners because they are smaller, cheap, and easy to fly. Meanwhile, hexacoptors are popular among those who have a few years’ experience flying drones. Octocopters, on the other hand, are used by the most experienced professionals for their redundancy, and stability. Safety features for drones have been enhanced to include a “return to home” function that activates when the drone goes out of signal with the pilot. At this point, the drone will stop and makes it way back to the original take-off point. One of the most prominent technological problems that drones face is the transmission of signals between pilot and drone. This leads to crashes and endangerment of the public and surrounding area, but this problem will likely be solved by anti-drone technology, technology that physically prevents the misuse of drones. But signal transmission isn’t the only problem, the operators that are breaking the law and flying near airports and other protected areas are causing most of the uproar about the negative sides of drones. That is where anti-drone technology comes in. From “invisible walls” that keep drones out of unauthorized areas to eagles that snatch drones out of the sky, anti-drone technologies are on the rise. However, anti-drone technology cannot be implemented automatically until there is a successfully tested device that can identify drones in the airspace. NASA is working on creating a UAV Traffic Management (UTM) system to track drones and unmanned aerial vehicles. With these “safety nets” in place, the publics’ opinion about the risks drones pose may disappear and will begin welcoming drones because of the great technology.

Drone technology is nothing without applications. The areas to which drones can be applied are endless, but the areas to which they currently are applied are limited by regulations. The technology has been applied in search and rescue operations by both police and fire
departments, as well as disaster relief and civilian outfits such as Search With Aerial Multi-Rotors, or SWARM. In addition, it has been used in numerous film productions on varying scales, from short music videos to feature films. Construction companies have used drones to map and inspect building sites as well as mining sites. Drones are applied in mapping technologies, creating 2 and 3 dimensional maps of our world and our structures. Drones being applied in these areas implement a new level of operation.

Maintaining safe airspace, especially as drones have become more common, is a task the FAA has completed commendably. Through aircraft registration, certificates of authorization and other legal means the FAA has been able to prevent drone-aircraft collision related fatalities. The FAA has also done a good job collecting data concerning reports of drone sightings, in addition to making some of that data available to the public. Citizen concern, especially about privacy, are not yet fully addressed by regulation. Commercial interests are required to file considerable paperwork and obtain lengthy/expensive certificates, to be granted relatively limited operational ability, but a better system should be put in place soon. States, counties and municipalities are frustrated because they can’t pass their own drone regulations- in fear of violating the FAAs uniformity of national airspace. Several legal suits have been filed against the FAA pointing out regulatory inconsistencies, and violations of congressional mandate. The steadfast reputation of the FAA has been contaminated by unaddressed citizen concerns, excessive commercial restriction, stifled municipal ordinance and contradictory FAA regulation.

Although regulation plays a big part in creating a safe airspace for drones, the public must be on the same page in order for successful integration to occur. The public is heavily concerned by the invasive nature of the drone technology. The most common concern for people is privacy: probing your daily lives/possessions, going into your backyard, and tracking your every move. The next most common concern is about the safety of the technology: drones falling out of the sky, crashing into airplanes, and damaging property. Getting the public on board comes down to adequate measures to prevent the misuse of drones, which takes well-balanced regulations and sufficient anti-drone technologies. However, the adequacy of these measures will largely be defined by how the media portrays
them. News agencies have an infatuation with drone strikes and the misuse of drones because—the way our culture is now—negative events attract more attention than positive ones. However, there are plenty of positive drone uses that just are not getting the same media and public attention that negative events do. In this way, public perception of the technology has been held back by fear and lack of information. To solve these issues, a conscious effort must be made by the media to cover positive drone events, and a vested interest must be held by the public to be aware of positive drone developments. To summarize, advances in technology may give drones more tools to operate with, but the utilization of these tools depends highly on public opinion.

This project has allowed us to discover an incredible number of innovative applications which we believe will fuel the future of the drone industry and encourage the development of better and safer technology. Advances in technology give drones more tools to operate with. However, the utilization of these tools depends highly on regulation and public opinion. Regulations in the U.S. have been sufficient, but they do introduce hindrances to the adoption of drone technologies, which limits its growth in several sectors. Furthermore, public perception of the technology has been held back by fear and lack of information. Regulation has a particularly interesting consequence on drone growth because in order to protect the public from fear of drone misuse, regulations must be introduced. However, in order to sustain a friendly environment for commercial use of drones, regulations must be streamlined. To put it simply, there must be a balance. We believe that by bringing the applications which positively affect society into light, we will educate the public and allow them to see a drone industry outside of the military.

The format of this project was originally a website, and it has been converted into a series of short essays compiled into a portfolio. Some of the media cannot be experienced as a result of the format change. To experience the full project please visit https://thedroneperspective.wordpress.com/.
Rogue Drone – Loose in the Amazon

Drone technology gone wrong!!?? I know you’re all thinking how could technology have caused a problem, it has advanced so much over the past decades? Well, I hate to break it to you, but it happens to even the best of drone operators. So how can we identify what went wrong and fix it before the drone causes an accident?

During filming of Treehouse Lodge [1] in Peru for Animal Planet, Chris Newman and Aaron Sorenson from CineChopper[2] experienced firsthand what it’s like to lose control of a drone. Their original goal was to film the making of the bungalows from start to finish, but instead ended up making a chase scene starring themselves and their drone. To make matters worse, it just had to happen in the middle of the Amazon Rain Forest.

Everything was working perfectly and going exactly according to plan until the unfortunate first day of shooting. This was when Chris lost control of his $15K drone. The drone suddenly stopped functioning and Chris lost the ability to operate his drone via his controller. So, he then found himself, as well as his partner, sprinting through the Amazon Rain Forest trying to capture the runaway drone. Fortunately, luck was on Chris’s side that day, for the whole event was captured on video by their Canon SLR camera that was mounted to the drone.

If you watch the related video, the drone is hovering along the tree tops for about just a minute and then decides to fly off on its own. The drone then descends within the next
minute or so only to crash into the top of a 60ft tree while slicing off some branches and leaves in the process. Thankfully, the only victim of the drone’s outburst was the tree. (The Phoblographer, 2014)

But what if we bring this scenario to a different environment? Let’s replace the Amazon Rainforest with a public city during early afternoon. Although the FAA states that drone operation should not be done near large groups of people, it isn’t really enforced. To make another good point, “There is always going to be stupid people that do stupid things.” (Roger Matus) So let’s have a pilot operating a drone and then the drone’s stops responding to the controller’s inputs. Now there is a rogue drone that is flying out of control in heavily populated areas. The “home” function is disabled and the only choice the pilot has is to watch his drone wreak havoc. The possibility for an accident similar to this is extremely likely. This drone could fly into electrical wires between telephone poles and cause a blackout, hit homes and cause property damage, hit a person square in the head and cause injury, start a fire after a crash, or even a combination of all four. Didn’t have to worry about that in the Amazon since it rains constantly. The FAA is increasing regulation enforcement for commercial drones after seeing the increasing number of dangerous incidents. (NY Times, 2015) The following cases are examples of the serve injury caused by drones.

The first one involves an 18 month old boy who lost his eye after being hit by a drone. Immediately after the incident, the boy was rushed to the hospital were his surgeon said that she had never seen an ocular injury caused by a drone, but with their popularity increasing it is inevitable that we will see a lot more. (BBC, 2015) Another incident occurred in Pasadena, California where an 11-month-old girl was injured after a drone crashed near her and her mother. The drone slammed into the ground and shattered pieces came flying right towards the little girl’s face. The young child was treated at Huntington Memorial Hospital for a large contusion on her forehead and a cut on the side of her head about a quarter of an inch long. (ABC7, 2015) Fortunately, neither of those cases were fatal, but with the increasing number of drones in the air that might change. If you would like to know more about these drone crashes you can visit the Democrat & Chronicle website and search domestic drone
accidents. (NYDATABASES, 2016) So how can we prevent these problems from happening in our everyday life?

Evidence shows that although drones are state of the art technology, they still have technological issues. Even today, many of the drone experts still say that “DJI[3] is a Godsend.” (Ty Audronis) Sending signals from the controller to the drone and vice versa is easily one of the most worked on technologies of the day. These signals can be quickly severed if out of a certain range.

Depending on material composition and thickness, signals through radio waves can be blocked or interfered. Thin quantities of plastic wrap, cotton, wax paper, and even rubber are highly unlikely to interfere with radio waves. One the other hand, aluminum foil, copper, and other electrically conductive metals, can easily reflect and absorb the radio waves causing inference with transmission. (Scientific American, 2011)

The most common radio frequency used for transmission between ground control and a pilot’s aerial vehicle is 2.4 GHZ. To put that in perspective it is about the same frequency of computer wireless networks. Due to this, drone operation in dense areas with many other wireless networks result in flyways and control loss. Another radio frequency know to quadcopter drones is 5.8GHZ which was uses to avoid similar frequencies in the same band. Note that both 2.4 GHZ and 5.8GHZ are considered line of sight (LOS) in which they do not function when there are any barrier between you and your drone. For advanced setups, some radio frequencies can range for many miles. (DroneFlyers, 2014)

The new technology buzz for drones is the ‘Return to Home’ function. DJI, 3D Robotics, Walkera Technology, and SOLO are just a few of the companies with this technology. (DroneZon, 2015) As stated earlier, when flying a drone the range of communication is the independent variable that controls the drone and if out of signal range the drone could just fall out of the sky. So instead of just plummeting towards Earth after disconnection, the ‘Return Home Function’ (RHF) activates as soon as the drone goes out of range from the controller and then automatically uses GPS data to navigate back to the take-off location.
Additionally, Parrot verifies that the RHF function is accurate to ±2 meters from the take-off position. This slight error is due to satellite variation. (ARDrone2_Parrot, 2012) Pretty amazing technology, right? Well for the regular 95% of the time yes, but for some cases not so much. Like losing signal right behind a giant cliff or building and have RHF activate causing your drone to smash straight into the massive structure. Well that’s just bad luck.

This brings up a good argument for the Federal Aviation Administration (FAA). Something that is lacking with the regulations of drone operation is basic knowledge and understanding of Unmanned Aerial Vehicle (UAV). Should the FAA reconsider the requirements when it comes to operating a drone? Maybe there should be a drone license test like a driver’s license test which includes in-class training (ground school). According to recent FAA activity and regulation, the idea of pilot ground school and sufficiency testing is likely to be implemented. This way the FAA can insure that the drone operators understand their drone, its functions, and its capabilities. Plus, everyone doesn’t have to get a pilot’s license which is very expensive and takes a lot of time. As one of our interviewer’s said “Just because they are a pilot doesn’t mean they can fly a drone.” (Ty Audronis)

With this possible improvement, I believe the FAA will be able to provide the extra support needed to improve the technology, and at the same time, be able to implement the regulations necessary to prioritize public safety.

We learned that even today drones are still faced with many technological problems and safety concerns. Which is why the FAA, as well as, the drone designers and manufactures are continuously working together to solve these issues with the overall goal of prioritizing the safety of civilians.

Unfortunately, Chris and Aaron had to experience this somewhat isolated scenario, but for the rest of the drone industry, it was a great learning opportunity. On a good note, they were able to personally see the techniques used to build the bungalows as those were the techniques used to retrieve their drone from the tree top.
[1] Treehouse Lodge – Hotel in Peru made from bungalows, the design is unique making it a special resort.


[3] DJI – Industry leading small drone manufacturer based in Shenzhen China

References


How can we make drones safer and more reliable – Is it the technology?

Technology’s job is to advance systems in a way that improves and enhances their capabilities, and at the same time makes them safer and more reliable. As we have seen with many other flying systems, technology has paved the way, and continues to pave the way, for latest and greatest next generation products. Hopefully, as the years pass, people will start to understand and rely on the amazing abilities that drones possess and begin to support their technological growth. The following story highlights the dangers drones possess when in the hands of irresponsible operators, and how improvements in the technology can make drones less harmful and more dependable, further preventing users from creating dangerous situations.

The minority of irresponsible operators have been flying drones too close to full scale aircraft and helicopters, entering unauthorized military airspace, spying on neighbors, disrupting sporting events, and even injuring people. It was only a matter of time before someone shot down a drone. The FAA as well as other law enforcers are having difficulty handling the rapid growth of the drone industry which may lead to very strict regulations that could hinder new innovation for commercial businesses. According to Gary Clayton, the chair of Unmanned Aerial Vehicle Systems Association[1], “This is a very hot topic. Operators with no training and no understanding of airspace could discredit the whole industry.” (BBC, 2015) But what if the technology can help?
DJI, the largest hobbyist drone maker in the world, is a Chinese company that holds a whopping 80% share of the drone market. Kevin Gordon, European marketing director, told BBC that several safety features have already been included in DJI’s latest Phantom quadcopter drones. Gordon stated “You cannot fly to the point where the batteries are exhausted. If you get to 10% of battery life it will automatically return to home and land.” Another safety feature is a geo-fencing system which uses onboard GPS and mapping to stop drones from flying into unauthorized airspace. Gordon claimed, “This is a solution to reduce airport incursion incidents. It’s important that we don’t allow people to fly in places they shouldn’t.” ([BBC, 2015](#)) Overall, this technology is not just for airports, but for protecting other unauthorized areas such as national landmarks and national parks from drones.

However, the possibility for technology failure is still there. It is unlikely, but possible to bypass GPS signals which would allow for drones to trespass over restricted areas. The latest technology is doing its best to counter-attack this flaw by allowing operators to specify the geo-fence area, reducing the risks posed by new, inexperienced pilots. In the overall scheme, “The next generation of drones will be easier and safer to fly, compensating for pilot error – we view this tech as making flying safer,” said Gordon. ([BBC, 2015](#))

Though onboard technology may be a step in the right direction, the use of other, more comprehensive technology, may be the best approach to keeping our skies safe. Currently, National Aeronautics and Space Administration (NASA) is investing in the development of a traffic management system for unmanned aerial vehicles (UAVs) that fly below 500ft.

Interested in testing the capabilities of this system, a team from the University of Nevada has partnered with Flirtey[2] and Drone America[3]. According to their research, hundreds of low-flying drones operating in the same airspace and carrying out different missions, such as deliveries, traffic monitoring, disaster relief, or even build inspection, will need a “sense-and-avoid” system so they don’t crash into each other as well as flight corridors, like the ones of passenger airliners. The system will also need to include up-to-date terrain mapping, dynamics route planning, and weather data integration. Hence, NASA believes a prototype of its air traffic management system will not be available until after 2019.
If the technology isn’t enough to stop drone from operating near airports, the FAA has issued penalties for violation of the regulations which can include a stiff fine and criminal charges. According to the Civil Aviation Authority (CAA) the endangerment of aircraft is a serious issue and they retain responsibility for raising awareness of safe drone operation and risks posed to aircrafts due to misuse. Only a few drone operators have been prosecuted for drone misuse, and no-one has been sent to prison. But until enforcers have a way to identify drones remotely (such as NASA Air Traffic Management for UAVs), and access to the owner’s central database, it will be hard to catch the growing number of perpetrators. (BBC, 2015)

Just to provide some numbers:

<table>
<thead>
<tr>
<th>Evasive action taken?</th>
<th>Number of records</th>
<th>Percent of total reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>No evasive action taken or evasive action unknown</td>
<td>392</td>
<td>51.3%</td>
</tr>
<tr>
<td>No reference at all or not applicable</td>
<td>362</td>
<td>47.4%</td>
</tr>
<tr>
<td>Evasive action taken</td>
<td>10</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

According to the Academy of Model Aeronautics (AMA), there have been 764 drone sightings by aircraft pilots just in 2015 only. (FAA, 2015) Out of these 764, the total percent reported that did not require evasive action or the evasive action was not reported was 51.3%. Another 47.4% of the reports were not applicable and did not have solid proof that they actually occurred. However, there have been 10 reports of aircrafts having to take evasive action due to drones. Although it only makes up 1.3% of the total incidents reported, that is still 10 flights in 2015 that had to take evasive action. (Provideocoalition, 2015)

With the increasing number of drones in the air, the number of evasive actions required is sure to increase as well. So what other technological solutions can be implemented to prevent these numbers from increasing? The first step could be in the manufacturing and design of drones. When designing a drone the question that should be asked before starting is “What are the environmental ranges that UAVs can withstand, such as pressure,
temperature, vibration, shock, and turbulence, before electrical failure.” (DfR Solutions, 2016) Commercial UAV’s can experience temperature variations from -40°C to 70°C, vibration, shock, moisture, pressure, and storage within their flying environment. By understanding impact these various stresses have on drone performance, manufacturers and designers can better improve the reliability by (1) Critical Component Testing and (2) a Physics of Failure based design analysis. After many years, the manufacturers and designers have been able to identify the most commonly failed components, such as electrolytic capacitors, connectors, optocouplers, oscillators, printed wiring boards, resistors, and solder joints. With this knowledge, supplier requirements, and reliability testing, proper screening through production can help reduce the associated reliability risk. Although the hardware is a small portion of overall system cost, it accounts for 80% of the final product reliability. (DfR Solutions, 2016)

One drone in particular that is paving the way in reliability is, the Gimball, a Swiss drone made by the company FlyAbility. The Gimball has awarded the Swiss company with a huge $1 million dollar prize after winning the “Drones for Good” international competition on February 7th 2015. Gimball, is known as the first “collision-tolerant-drone,” which utilizes a rotating spherical outer cage that surrounds the drone body, propellers, sensors, and camera if equipped. This way when it collides with other obstacles the Gimball just bounces off without taking any damage. The design was inspired by a fly bouncing against a window when it tries to escape. According to co-creator of the Gimball, Adrien Briod explained, “We were wondering why insects were so capable of going inside any building — yet had limited senses such as eyesight. One capability that was completely overlooked was their ability to collide into surfaces. For insects this isn’t a big deal — but it is for robots.” (CNN, 2015) The Gimball maps it surroundings and can roll across ceilings and floors, navigate restricted areas, and send RGB and infrared images back to the operators.

One organization was interested enough in testing the Gimall that they teamed up with FlyAbility to test the use of the Gimball drone in their work field. They are a mountain recuse team for the Zermatt Glaciers in the Swiss Alps. They used the Gimball to explore some of the glaciers frozen chasms that often cannot be seen by humans. While it went down about 10
meters, it transmitted real-time footage that the rescue team could clearly see. For these mountaineers, the Gimball could help identify people who are trapped in the deep caves, jagged faces, and narrow spaces making it easier to rescue them and at the same time making sure it is also safe for the mountaineer to safely proceed with the rescue mission. Overall the Gimball drones proved to be perfect for these kind of treacherous environment rescue operations. FlyAbility believes that it is going to be a valuable search and rescue drone that will be used to scan disaster zones like nuclear sites or battlefields for survivors, and after returning from the depths of the Zermatt Glacier unscathed, it might just be up to the task. (Gizmag, 2016)

The use of drones in place of humans for security, search & rescue, firefighting, and law enforcement would be one of the most beneficial investments. The life of a human is irreplaceable, but for a drone it is easily replaced. The advantages of using the Gimball in place of firefighters or law enforcement officials are (1) it can enter a building/structure though any opening larger than 1ft and 35cm, (2) it gives instant visual assessment of the situation allowing to identify victims and/or dangers, without sending personnel in unknown or dangerous environments, (3) it provides no risk of hurting bystanders or victims with the robot, and (4) it requires little training to operate and is easy to fly out of the pilots line of sight. When flying in contact, the HD camera on the Gimball can detect features up to <0.2mm and has its own lighting system with a 360° view. Talk about reliable, if this type of technology were implemented it could increase survival rates drastically. (FlyAbility, 2016)

[1] Unmanned Aerial Vehicle Systems Association – A trade body representing several hundred commercial drone users


References


Drone Proofing Airliners?

Breaking news on CNN showed two different airplanes interrupted by a drone at one of the nation’s busiest airports, John F. Kennedy International Airport (JFK). According to audio from both flight radios the drone was within 100 feet of each of the aircrafts.

The first incident happened at 2:24 p.m. with JetBlue Flight 1834 when the pilot spotted a drone approaching the aircraft, according to the Federal Aviation Administration (FAA). From the audio recording, the pilot said that the drone flew just under the plane’s nose when the aircraft was at an altitude of about 800 – 900 feet. The second incident happened at around 5:00 p.m. on the same day. This airplane was Delta Flight 407. The flight had 154 people on board. As the plane was preparing to land the cockpit reported seeing a drone below its right wing. Fortunately, neither aircraft needed to take evasive action and both planes landed safely. Though it’s unclear whether the two are related the FAA is conducting an investigation of each incident. (CNN, 2015)

CNN reported it was commented as a “Dangerously close” call. The Delta Flight 407 encounter the drone right around Floyd Bennett Field, located in the Gateway National Recreation Area (GNRA). Unmanned aircraft systems (UASs) are not supposed to fly within five miles of an airport unless they notify the airport operator and control tower. Additionally, the regulations for drones includes no flight beyond 400 feet in altitude. To shed some light on the situation, the FAA informed us that they get approximately two
reports per day and about 60 per month from pilots saying they spotted an unmanned aerial vehicle (UAV).

This article in particular caught the eye of CNN aviation analyst, Mary Schiayo. Mary knows that even without the latest regulations it is still illegal to fly drones near any major airport, but what she doesn't understand is why they do it. She believes that with the new penalties, including jail time, from the FAA regarding airport regulations will prevent people from not just flying near airports, but from doing stupid things in general.

According the Phil Derner of NYCavitation.com drones pose a serious danger to large scale commercial flights. Drones can be sucked into the engine or even smash into the cockpit window. These two accidents could be devastating. One, the engine could blow up and get destroyed and two, the pilot may be injured or killed if hit by the drone. However, if we consider some other scenarios like the drone colliding into the wing or another part of the aircraft we may be in a tight situation then too. Just think if pieces of the drone got stuck in the ailerons or flaps of the wing making them inoperative or taking out some of the sensors on the aircraft that reports data back to the pilot. With these incidents the pilot can be consider "blind" when the aircraft isn’t telling them what it is experiencing. They could have a fire in the engine and wouldn't even know because the sensor got damaged. Each of these events, even just spotting a drone causes distraction for the pilot and is a very dangerous position to be in when there is bad flying conditions or low altitude flying. (Gizmodo, 2013) Looks like Mary had a good reason to be concerned.

Even Karen Walker, the Editor-in-Chief of Air Transport World, believes an airliner full of passengers and crew is going to be brought down after colliding with a drone, sooner than we all expect. She believes the FAA, IATA, ICAO, aircraft manufacturers, the airlines, law enforcement, and governments should be doing something about the quickly intensifying danger that drones possess toward commercial air transportation. The threat to airliners from drones is much more likely and more prominent than airliner tracking, military/CIA communications with commercial air transport authorities, or psychological monitoring of pilots. (ATW Online, 2015)
But this isn’t the only thing that has CNN analyst Bob Baer and Jonathan Gilliam worried. Their concern is focused on how the drones could be used to purposely attack planes. Bob makes a great point: all you need is a drone and 3D printer that makes drones out of explosives. He knows that drones are advancing at a rapid pace and they are very dangerous because of it. Baer and Gilliam believe that airports should consider jamming signals to drones or just “knock them out of the sky.” (CNN, 2015)

Honestly, I think it would be pretty cool to have official “drone testing” for commercial aircraft engines so that we can insure that drones would not be a problem for engine functionality. But it looks like we won’t have to do that. Instead we are going to keep drones out using new advanced anti-drone technology. It will certainly save money and improve efficiency, and since nobody knows what kind of damage can be produced from a drone-aircraft collision it probably isn’t worth it.

Former chief investigator for the National Transportation Safety Board, Ben Berman, thinks that drone manufactures should install software that, restricts their flight to keep them within regulation of the FAA, before selling them to the consumers. The FAA has hinted at a software update for all drones known as “geo-fencing” which may provide a short term fix for airport safety, but does not require all small drone manufactures to install this update. (Scientific American, 2015)

DJI, one of the best-selling-drone manufactures, based in Shenzhen China, has already taken action. They are the makers of the world’s most popular small drones. Since 2014, DJI has produced drone firmware updates to enforce the restricted airspace around airports, Washington D.C. or national borders. Operators that ignore the software warnings will find their drone’s non-operational and basically “brain” dead. This new software that enables what drones can and cannot fly over is known as a type of “geo-fencing system.” The basis of the system is using the drones built in GPS to compare it to areas on a map. If the drone is trying to enter a no-fly-zone or restricted area the geo-fencing system will activate and send a warning to the pilot via an app that they should stop entering or exit the area. If the pilot decide to ignore the warnings the drone will refuse to listen to the pilot and not enter.
(Fortune, 2015) As DJI’s Michael Perry said, “It’s like flying into an invisible wall.” (Scientific American, 2015)

However, there is a self-authorization option that will enable pilots to fly in specific locations if they create a DJI account. In order to make an account, you will need to verify a credit or debit card and a mobile phone number, but the information will be available if there are legal investigations of flights. Other than that the information will not be collected or stored for any other purpose. The self-authorization system does not work for national security locations such as Washington. According to Brendan Schulman, vice president of policy and legal affairs at DJI, “This is an example of the technology empowering operators to make smart decisions.” (The New York Times, 2015)

Based off the new regulations, various companies other than DJI have decided to join the FAA’s registration task force. Some of the parties interested in helping to influence the regulations include, Google, Amazon, GoPro, Parrot, and 3D Robotics. (The New York Times, 2015)

Even though drone testing airplanes seems like a real blast, it looks like everything is being handled pretty well without it. The benefit of implementing regulation into technology may help to spark new ways of integrating technology and the law together that can further protect our society. The FAA has teamed up with Consolidated Analysis Center Incorporated (CACI) International, a federal IT, intelligence, and military contractor, to test “technology that identifies unmanned aircrafts near airports. They have made programs called “Know Before You Fly” and “No-Drone Zones” to raise awareness about the areas drone operators are not allowed to enter. (DefenseOne, 2015) Even NASA is getting involved! Currently they are researching the technology to create an air traffic system that could track small, low altitude drones. (Scientific American, 2015) Looks like drone proofing airliners is out and added new regulation software to the main drone is in.
References


Can We Stop Drones with Drones?

There are many people that are concerned with drones for privacy reasons and drones taking photos over their backyard. What they don’t know is the real harmful things drones could be capable of. I am not saying privacy invasion isn’t harmful, but it isn’t fatal. Just think, what if a drone is equipped with a bomb and then flies into the middle of a mall and detonates killing hundreds. I think a drone simply flying over a backyard is not as serve as a bombing massacre, but that’s just my opinion. Well not to worry, it doesn’t matter which one you think is more important because anti-drone technology can stop them both!

Currently in the United States anti-drone technology is still fairly new but is making some great progress. As of now, there are two main anti-drone technologies that are being worked on. The first is the DroneDefender, made by Battelle, a major government contractor that helps manage some of the country’s national laboratories and regularly makes scientific breakthroughs and discoveries. The second is NASA’s UAV Traffic Management (UTM) system. So what are these and how are they stopping drones?

Battelle’s DroneDefender is a highly complex system that uses radio waves to match the frequency of drones neutralizing them in-flight and forcing them to land. The DroneDefender is designed as a point-and-shoot system that looks like an elaborate shoulder ray-gun with two antennas, a specialized software radio, and a jamming system. “It works by firing a radio beam in a 30° cone that jams the control and GPS navigation
frequencies to disable drones at distances of up to 400 m or 1,300 ft. Battelle says that the system not only freezes the UAV, but also stops all outside control commands, including radio detonation signals." (Gizmag, 2015) According to Dan Stamm, developer of the DroneDefender, “It basically makes the drone think that it’s gone out of range. The drone enters into its safety protocols which include one of three options. It’ll either hover in position until the pilot can regain control link, it lands so the pilot can recover it physically, or it returns to its point of origin.” (Motherboard, 2015)

Although other companies have tried making devices to try neutralizing drones, the DroneDefender is the first successfully tested device that can take a drone out without damaging it. It has been tested against DJI Phantoms and effectively responds during field testing. However, a drone without any safety protocol will not be effected by the DroneDefender and just keep flying. Stamm claimed that several federal agencies are already lined up to purchase the DroneDefender which will be available next year.

On the other hand, NASA is researching technology to create an air traffic system that could track small, low altitude drones. (GNC, 2015) According to NASA’s Safe Autonomous Systems Operations manager, Parimal Kopardekar, NASA wants to create a system that can keep track of drones and deliver critical information to the operators via the UAV, such as areas that are unauthorized or if there are other air vehicles in the same airspace. Currently, the NASA team is exploring and testing ways to communicate this data to the UAV during flight, such as geo-fencing and virtual barriers, which will transmit the most updated real-time information to the UAV. As of now, NASA envisions two types UAV Traffic Management systems (UTM) (1) a portable system to monitor operations, it can move to various geographic locations and (2) a persistent UTM system that would give continuous coverage of low flying drones in particular locations. NASA has also decided to explore tracking low-altitude drones with cell phone towers. It is still in the early stages, but the idea behind it is that the system would monitor drone activity across the Verizon cellular network through the sensing equipment on board the aircraft.
However, the US is not the only one dealing with these drone issues. Other countries around the world are facing the threats drones pose. Some of the more prominent countries are Japan, the Netherlands, and England. In Japan, a drone was caught carrying radioactive sand and landing on the Japanese Prime Ministers House, now the Tokyo Police have started to implement there interceptor drone to catch these dangerous unauthorized drones. (The Verge, 2015) The six-rotor interceptor drone carries a 3m-by-2m net, and will only take to the air once an unlawful drone has been spotted. After entangling the offending drone, it can be gently carried to the ground. The Dutch, believe it or not, are using eagles to stop out of control drones. They have teamed up with Guard From Above, a raptor-training security firm based in The Hague, and are currently training eagles to take them out of the sky. (The Guardian, 2016)

London, has taken its own approach to anti-drone technology. The UK defense company, Selex ES, revealed its sophisticated anti-drone defense system in fall of 2015 at the Defense and Security Equipment International Exhibition in London. They had been working on this since back in 2012, but have finally unveiled the Falcon Shield, a protection systems against mini- and micro-UAVS. It was designed to protect military soldiers, convoys, and bases from weaponized drones. (Digital Trends, 2015) According to Selex ES, the technology has been confirmed to take advantage of the electromagnetic system and create a shield around a specified area. The Falcon Shield utilizes a network of camera and radar sensors that can pinpoint a drone’s location and track it. Other than detection, the Falcon Shield has offensive capabilities ranging from jamming and hacking to shooting projectiles or bullets at an authorized drone.

Countries around the world are all challenged by drones. The risks, dangers, and misuses that they are capable off and what could happen if they got into the wrong hands. But it looks like everyone is already taking the steps to counteract these threats. Good luck to the future drone misusers because the rest of world is already waiting to implement their anti-drone technology.
References


The Next Generation of Drones: Engines!?

Ever think what would happen if a drone was made with an engine instead of a motor? Well, keep a look out because it may be happening in the near future. Over the course of history, we have gone from the Wright brothers to the DJI. Aircrafts were the first evolution in the aerospace industry, but as the years passed we upgraded from the P51- Mustang to the F22 – Raptor. The rapid advancement of the aerospace industry has led to the creation of drones. First used in the military, drones were surveillance detectives. Their purpose was to spot enemy territory and send information back to the US operators what enemies were planning or doing. After a few years of use in the military they became a public toy. They kept on developing and are now being used for commercial purposes. I decided to make this article mainly about the technological improvements from quadcopters to hexacopters, hexacopters to octocopters, and octocopters to drones with engines.

First let start with the most popular drone in the market, the quadcopter. Quadcopters are fast, easy to manufacture and come at an affordable price. Quadcopter drones make use of four propellers, hence the prefix quad- meaning four. The common configuration of these four propellers is in a square or rectangular design around the body of the drones. So what are the benefits that quadcopter drones have that separates them into a class of their own (UAVs). Well for one, they have fours propellers, so they can produce more power to lift off the ground. This in returns, gives the operator more flexibility when it comes to weight and payload that he/she wishes to embedded into the copter. In summary, quadcopters are
relatively cheap to manufacture, have great maneuverability are powerful enough to add accessories, and have greater thrust and power than that of bi- and tri-copters. This type of drone is suggested for hobbyists because the models are readily available, easy to repair, and are within a reasonable price range. But it is not as good as its “brothers.” (Dronebly, 2014)

After quadcopter comes the second older brother, the hexacopter. I am pretty sure you get the point, but just in case these hexacopters are equipped with six motors and corresponding propellers. The extra propellers and motors add to the aircraft capability and makes it an optimal choice for anyone interested in attaching an expensive camera. The hexacopter has all of the capabilities of a quadcopter, but better, and then some. Hexacopters have higher speeds and more power due to the extra motors and propellers. It can easily fly higher in the air than a quadcopter and reaches higher elevations with ease. Probably one of the most important feature is the safety factor. By having 6 motors 120° apart, it allows for failure in one of the motors. If one motor gets damaged the other 5 can work overtime in its place. This means that the pilot can safely land even if there is a malfunction in one of the engines. But with a quadcopter that would be an entirely different story, let’s just say the odds are good you might just be getting a new drone. Some pilots have even gotten away with landing safely after two motors died. This is where the positioning of the motors is critical to whether you can land or crash. Also keep in mind that with more motors there is more power so you can carry heavy payloads or better high-tech gadgets to equip on your drone without any problems. Overall, hexacopters provide greater power, speed, elevation, a higher payload capacity, greater flight control, and better safety. However, a hexacopter is larger in size and harder to fly in tight spaces, the motor parts are more expensive if they need to be replaced, and the price tag is much higher than a quadcopter. (Dronebly, 2014)

The hands down best multi-copter is the octocopter (Picture Below). As like before, the octocopter has all of the beneficial uses as a hexacopter, but with even more power due to its additional two motors and propellers. These aircraft are not cheap, but are ranked number one for professional videographer drone. With much more speed and agility than the hexacopter it can easily take on the other competition. The control is outstanding and inference with bad weather does little to make it worse. Similarly with the hexacopter, the
Octocopter is capable of flying evening with one motor down, but it also has the room to operate with two or three motors down depending on the placing of each motor and the overall payload. So if you decide that you want to strap a $2,000 camera on your drone to get awesome photos, then this is the drone model for you. Octocopters are made to fly and have true control and stability. To summarize, octocopters are very fast and agile, can reach exceptionally high elevations, are extremely powerful, can hold heavy equipment such as cameras, and are very safe and stable. However, there are a few downsides to octocopters, (1) they are very big in size, (2) they are extremely expensive compared to both quadcopters and hexacopters, and (3) the battery life is consumed much quicker than with a quadcopter or hexacopter because of the size and weight. Currently, octocopter manufacturers are working on increasing the flight time. As of now, the flight time is around 10 minutes and it takes a crazy amount of time to recharge. Even with the increase in flight time, payload weight and flight conditions will need to be taken into account after the upgrade. I would recommend using an octocopter if you need a drone that can withstand harsh weather conditions and carry the latest and greatest camera gear. ([Dronebly, 2014](http://dronebly.com))

([Florida UAV, 2016](http://florida-uav.com))
When deciding which kind of drone you would like to purchase you should keep these facts in mind. A quadcopter is inexpensive and less durable. They are perfect for beginners and non-professionals. The hexacopter is a great choice for semi-professionals or hobbyist that want a very durable, steady-flying copter that can carry a fair amount of weight. The octocopter is the top of the line. They have a hefty price tag, but they have the most power, stability, and speed out of any other drones. Their advanced functionality and stabilization features make the octocopter a must-have for professionals. (Dronebly, 2014)

After establishing how awesome 8 motors are what could be a better, well there is the possibility of drones with engines. Rotron, an advanced rotary engine technology manufacturer is working towards producing UAV, Target Drone, and Vertical Take-Off and Landing (VTOL) propulsion. They are currently working with piston engines and refining the relationship between efficiency, propulsion, reliability, and size. Engines can be big, heavy, and use a lot of fuel, and Rotron knows this. They have come out with a new series of engines known as RT300. (Rotron, 2016) The RT300 has proven it’s durable for operators looking for high power to weight ratio with increased efficiency. The engine size is small which allows for greater fuel and payload flexibility for various mission capabilities. At medium to high rpm ranges the engine produces low levels of torsional vibrations and zero radial vibration. Fuel injection and the engine control unit (ECU) are adjusted according to altitude. The engine also has higher endurance making for longer flight time. It is available in both push and pull configurations with either direct or reduction drive. Overall, this single rotor piston engine uses the most up-to-date rotary technology and premium materials that result in industry leading performance, in a lightweight, reliable, and efficient package.

Now although the engine is pretty remarkable, I don’t think it is for all UAVs and drones as it currently stands. Using an engine in place of a motor would give longer flight time, but it would cost a lot more to keep it running and safe. Also, it isn’t small enough to be used in the average sized drone. Weighing about 47lbs, it is too heavy to put in a normal quadcopter or UAV. The diagrams below show a few pictures outlining the specifications, performance, dimensions, and components of the RT300 piston engine. (Rotron, 2016)
As of now, engines are still a ways off to be incorporated into drones, but if we can make smaller, lighter, and less powerful that may be the next big thing for drones.

References

Drones for Every Species

We live on a planet that is inhabited by thousands of species. Our enhanced cognitive abilities allow us to study, learn and modify our surroundings to benefit us all. In order to learn about Nature it is important to build an interface that helps us collect information and be able to assess it. The drone industry has extended its wings over the scientific research community providing them with a powerful tool to gather data efficiently and cost effectively. The benefits of using drones – also known as unmanned aerial vehicles (UAVs) – in wildlife research can already be seen around the world, from capturing poachers to saving human lives from shark attacks. It is remarkable how much a small UAV with a camera attached to it can help you reach places that couldn’t be accessed before.

Ecologists like Lian Pin Koh, are pushing for the need and use of drones in conservation across the world. Koh, is an associate Professor at the University of Adelaide who, along with Ecologist Serge Wich established ConservationDrones.org which shares information about the various NGOs and academic groups that use and develop drones specifically for wildlife research. In an interview with Yale Environment 360 (Gammon, C.), Professor Koh described the challenges the teams faced...
during an Orangutan Population study in Sumatra. The study originally required researchers to walk around the rainforest, count and map the nests. This job was tiring, dangerous and extremely time consuming. As the funding was running low for the research, Professor Koh provided the team with a hobby-grade UAV prototype with a camera that could photograph the forest. The cost of the prototype was less than a thousand dollars making this method to be extremely efficient and cost effective.

Poaching activity has increased an alarming level around the world, from Tigers of Thailand to the Elephants of Kenya. One of the critical cases is the pursuit of the South African Rhino where every day 3 Rhinos are hunted down for their horns. 400 rangers of the Kruger Game reserve find it difficult to handle the situation and is impossible to control an area of almost 20,000 square km (Academics. H). In 2014 the Wildlife Conservation UAV Challenge was introduced to foster the innovation and utilization of UAVs to assist with counter poaching and illicit wildlife trafficking. One of the entries to this competition was the Ranger Drone Project from the HEMAV Academics team, which addresses the poaching epidemic in South Africa.

This provides the National Park staff with the tool to broaden their surveillance capacity. A fleet of autonomous UAVs (cameras and sensors including) gives the Rangers a bird's eye view and real time information. The ground station for these UAVs is mobile and consists of a laptop, GPS, and communication system. Meanwhile, the UAVs utilize 3G for long distance
communication with both the ground station and other units. Each drone can be assigned certain airspace to patrol over and can consistently provide feedback to the rangers. Furthermore, infrared cameras allow the UAVs to be used at night. This tool helps the rangers detect poachers before they get to the animals. Sensors on board the UAV can (1) detect the weapons the poachers are carrying, (2) estimate the proximity to the animals, and (3) provide the best route that the rangers can take to stop and capture the poachers.

The Ranger Drone Project is one out of the numerous examples. Researchers have pushed the limits of these UAVs by operating them in the rough weather conditions and have emerged with stellar results. The Scientists from the University of Alaska Fairbanks along with NOAA’s National Marine Mammal Laboratory conducted a population study on Sea Lions in the Alaskan, Aleutian Islands. With winds up to 30 knots, precipitation, and swells over 10 feet, a single Aeryon Scout Micro UAV was flown for 6 hours with 31 flights. The scout captured over 60 gigabytes of data, which were then used to accurately determine the sea lion population including their gender and approximate age. Data of this quality would simply be impossible to be collected on foot or by a ship encircling the islands (Labs. A).

Expanding this horizon to the marine life, Ocean Alliance in collaboration with Olin College are developing a technology that proves that you don’t have to kill a whale to learn about whales. Snotbots, which are small and cheap drones can be launched by researchers from the boat as soon as a whale is spotted. The drone equipped with sponges can fly over the whale and collect the blow which is basically snot – mucus and lung lining that tell the
scientists about stress hormones, DNA, toxins and diseases in the whale. These drones allow the data to be collected without hurting the whale and without them knowing.

This entire package can be produced for about 2850$ including cameras which transmit First Person View to the pilot. The whale surveys that are being done today use airplanes that fly low and slow, so they are expensive and extremely dangerous. Once people realize what drones are capable of at this affordable price it could open a tsunami of opportunities for scientists (Milkman, H.).

That being said, drone use for wildlife research may have a downside. Drones can seriously stress out wild animals even if they are not showing it. A study from the University of Minnesota describes researchers terrifying some black bears for the sake of Science. They flew a small quadcopter over 4 wild bears that were equipped with heart rate monitors and GPS trackers. The drone never got closer than 46 yards to the bears, but they panicked anyway. Even though they didn’t act frightened the heart rate monitors recorded huge jumps every time the drone came near (Ditmar, M. A.).

This study supports the concerns of the National Park Service, which banned the use of private drones within the parks due to noise, frequent crashes, and the concern that they may be affecting wildlife. Despite this, they permit some drones to be operated as a part of research, firefighting, and search and rescue. However, the researchers are likely to conclude that the benefits still outweigh the risks.

Wildlife research depends on the ability of a drone to assess an area and collect the required data. Moving onto the next stage of this technology researchers like Dr. Thomas Trappenberg at Dalhousie University focuses on augmenting these research drones to autonomously fly around and make decisions. One example would be automatically tracking the research ship’s location, finding the path back and landing on the deck without any human assistance. This simple task requires the drone to be equipped with algorithms to help them anticipate the motion of the ship on rough waters and adjust accordingly.
The development of improved technology will most probably result in quieter rotors and anti-crash systems, making the use of drones in wildlife research more prominent. This would ultimately help us study and save the wildlife in their natural habitat.

References


Mapping the Way of the World

In this world it pays to know what is going on. An essential part of that is mapping the world around you. Planes and satellites can be costly though, and the more traditional means are time consuming. This is where drones come in to play. Using a variety of technologies, drones can assist in mapping our physical world.

LiDAR, meaning Light Radar, is a camera technology using lasers. The camera sends out a beam of light in a specific direction, which bounces off the surroundings and returns back to the camera. The changes in the light waves is recorded as a various set of data, including position relative to the source. This is useful in mapping technologies because using LiDAR over an area gives a set of points which can be arranged into a 3 dimensional model. Applying this to drone technology, one could create large area maps due to the stability of multirotor craft at certain heights.

Visual spectrum imaging is exactly what it sounds like, a camera. With how fast drones can move from point to point, cameras are a very useful tool for aerial mapping, and covering large areas is relatively easy. This gives an advantage to anyone who wants to update maps on a regular basis and needs to do it cheaply. In the past, to photograph areas or plots of land, civilian mappers had to hire an aircraft or satellite to take the photos, which in all cases would be expensive. With drone technology, this can be done cheaply, and can be done on a regular basis. (Kliegman, 2016) With a couple hundred dollars, anyone can purchase a drone
and, after registering it with the FAA, load it up with mapping software. This means that drone mapping is a very viable application in the future for a variety of industries.

One such industry is construction and mining. Drone companies like Kespry or Sensefly offer services in drone mapping to a variety of industries. Kespry in particular works with construction and mining sites to create quick, accurate assessments of the area. Using a variety of cameras, they can map elevation and take images of sites to provide the information to the building company. (Kespry, 2015) Below is a video by Kespry on using drones in mining.

With how simple drones are becoming to fly, construction and mining companies can very easily adapt to this technology, and those that do will be far ahead of their competitors. Accurately assessing construction sites and mapping current building progress are both applications that can benefit from the use of drone technology.

During Natural disasters, landscapes change overnight. From hurricanes to tornadoes, floods to earthquakes, damage is done not only to human structures but also to the landscape around us. This causes trouble for disaster relief efforts trying to find and rescue stranded individuals. Drones help with search and rescue in many cases, which can be read about in the article titled, “Drones in the Pursuit of Saving Lives”. In the days following Hurricane Katrina, many small towns were cut off from the rest of the world due to blocked roads and downed phone lines. One such town was Pearlington, Mississippi. Disaster relief had no idea if there were any stranded people within Pearlington, and had no way to get into the town to check. The Center for Robot-Assisted Search and Rescue, or CRASAR, flew small drones into Pearlington to assess damage and search for any people who could have potentially been stranded. Thankfully there were no stranded, but the use of drones in this situation was one of the first in disaster relief. (Murphy, 2015)

Using the technology explained above, disaster relief could very easily map and assess disaster hit areas. Being able to quickly determine which roads are blocked, which areas are in the most danger, and where the most people would be are three things which would allow
disaster relief efforts to respond quickly and efficiently. Using LiDAR and other cameras, they would be able to map roadways and urban areas very quickly and be able to reach more remote areas quickly, addressing the needs of the affected area more efficiently.

Drones are a staple of future technology, and in many areas they assist in making operations quicker and cheaper. Using cameras and mapping software, drones can easily revolutionize the process of mapping our world, and its many facets. From construction zones to earthquake ridden areas, drone mapping is soon to be an amazing tool.

References


Drones: The New Steadicam

The use of drones in filming has a history almost as long as the idea of unmanned quadcopters. Ever since the idea of an unmanned aerial vehicle was conceived, someone thought to put a camera on it. The idea also contributed to satellite cameras in orbit, such as the google earth satellites. Being able to take photographs and video remotely gives a huge advantage to the users. However, using drones in film was not allowed until mid-2014 in the United States.

Drones are currently being used in a variety of different applications, from short films and sporting events to major motion pictures. Small film companies like Corridor Digital, who make short films about video games and pop culture topics, have used drones as a filming tool for a couple years. One of their most famous videos, titled “Superman with a Go Pro,” is shot from the point of view of Superman much like how athletes wear a Go Pro camera while performing sports. Flying around Los Angeles, the video leaves one wondering how they achieved the spectacular shots. Using a DJI phantom, one of the first commercially available filming drones, they were able to get a perspective similar to that of a superhero. Since the release of that video, Corridor Digital has upgraded to a DJI Inspire, one of the newest and easiest to operate drones in the film industry today. Easy to operate, with the right permissions this could be a game changer in the short film world. (CorridorDigital, 2014)
Drones have replaced helicopters in most instances of filming from the air. The advantages include being able to be flown indoors, drones are cheaper to fly and are easier to acquire, and the drones do not disturb any set as much as a helicopter. The Los Angeles Times reported that it costs as little as $5000 a day to operate a film drone, as opposed to $25000 for a helicopter. (Verrier, 2015) Drones are more versatile than helicopters, being smaller and in some cases faster than the helicopters used for filming. In addition to these aspects, drones are able to be flown inside, unlike even the smallest of helicopters. An example of this is artist Mary J. Blige’s music video for her song “Doubt,” shown below.

In the video, the camera flies around a theater, filming the artist singing on stage. Starting at about 1:10, the video shows the empty theater, no wires, no crew, and then flies toward the entrance. None of these shots would be possible with a helicopter, and the alternative to using a drone would be incredibly large set ups that carried a cameraman through the air. This video was almost entirely possible because of the use of a camera drone.

Athletes use drones to film their active lives. For surfers and snowboarders alike, drone technology allows the documentation of their activities. Usually operated by another person, the drones can easily follow quick moving targets and film from a variety of angles. However, technology has been developed so that the need of another operator is nonexistent. Drones can use tracking technology to follow the user as they traverse terrain. Lily is one such drone. (Lily, 2015) Using a small controller, Lily can be set to follow the controller or hover, filming anything happening. Lily can also be used to take still images, marketing that aspect towards families in one of the advertisements. Many athletes film themselves using these technologies, but drones have been banned in the recent years from going within 3 miles of a large sporting event. It wasn’t until last September that the Federal Aviation Administration, or FAA, approved a sporting organization, the National Football League, for the use of drone cameras at stadiums. However, the FAA limited NFL Films, the NFL’s video production unit, to flying drones only within empty stadiums. This is in line with the FAA regulating use of drones to uncrowded areas. (Cox, 2015)
Many films have used drones for a variety of camera purposes, such as close up shots that track out to film the entire scene. This can be seen in films such as The Wolf of Wall Street (2013) and Skyfall (2012). (Amato, 2014) The drones used to do this are light, small, and don’t cause much disturbance, so they can be flown relatively close to actors. This allows for shots never possible before. Drones have also been used as early as 2002 in Harry Potter and the Chamber of Secrets, filming rolling landscapes and countryside. These early applications of film drones were mainly used as backdrops, and were not the primary camera.

Drones have already opened up new possibilities in the film and video industry. With the potential to revolutionize the industry like Steadicam technology back in the 1970s, the future could see even more usage of this technology. As of October 2015, less than 10% of productions had used drone technology to film (Gamerman, 2015) but it is a growing industry and a growing technology that can only be more useful.

References


An Agricultural Bloom

Precision agriculture is defined as a farming management concept based on observing, measuring, and responding to inter and intra-field variability in crops. Intercrop variability refers to crops in specific areas of a field doing better than others. Intra-field variability refers to certain fields (usually of a specific crop type) doing better than others. Drones can be used to collect information about and address in-field issues, which helps crops grow at optimal rates. There are two types of drone platforms: multicopter and fixed-wing drones. The advantages of fixed wing drones are that they can cover large areas in relatively few battery cycles. The advantage of a multicopter drones is good stability for visual and assessment tools. The adoption and implementation of Unmanned Air Vehicles into precision agriculture depends on the public’s support and the regulations.

Of the regulations governing the drones in Precision Agriculture (Discussed in articles under the Regulations section), the most difficult for farmers to tackle is getting the pilot’s license needed to fly drones commercially. Because the vast majority of farmers don’t have or want this license, right now, even if a farmer is interested in using drones—he/she will most likely have to reach out to companies that provide precision agriculture drones as a service. This limits how much farmers are willing to use drones because they need to pay and coordinate with a third party to get images of their fields.
Many farmers have already adopted precision agriculture drones that estimate crop yield because it has clear implications on a farmer’s ability to sell his/her crop come harvest time. However, the extent to which a farm can be better off by using assessment techniques that help conserve and correctly distribute resources is less clear. To some, research in this area feels like a pseudoscience; most studies conducted on this topic have largely been inconclusive. There are simply too many variables, the most significant of which being crop type. Vegetation indices are especially susceptible to crop type; although as it stands, these indices are supposed to be universal. Normalized Difference Vegetation Index NDVI, which is used to assess plant health and water quality, for example, has been inconsistent for both corn and cotton.

Farmers need hard proof that the technology is economical before they can implement it. In the Midwest, an abundance of pioneering farmers fighting for a competitive edge has resulted in a rapid adoption of drone technology. The yields and revenues of these pioneering farms will provide an abundance of data in future studies and censuses. Once adequate data is available, hesitant farmers will be much better able to gauge the economic benefits precision agriculture drones offer, and they won’t have to rely on inconclusive studies and companies trying to make a buck.

This rapid adoption, however, tends to occur on a regional scale. Farmers are influenced much more by what their neighbors are doing than what research says. This means that adoption of drone technology will often be confined by geography and accelerated by the density of farmers who are growing the same crop.

The rapid adoption is also accelerated by scarcity of resources and economic pressure. One of the reasons why precision agriculture drones are taking off so quickly in the Midwest is because much of the water access in the Midwest is based on a depleting ground water reserve. In areas with heavy competition, the adoption is accelerated even further: farmers who need to find a competitive edge to survive are more willing to take risks on new technologies than farmers who are in more steady and less competitive markets.
There are several factors that might accelerate this adoption in the future:

- The most inevitable of these changes is that technology will improve; if researchers can improve the consistency of vegetation indices to account for variations by crop, farmers wouldn’t have to be so hesitant about adopting the technology.

- Another virtual guarantee is that the market and economy will be subject to change: economic woes and increased competition may put more farmers in a position where they have to take risks, like investing in drone technology, to survive.

- The adoption of this technology might also be driven by necessity: depleting resources might force farmers to accept resource conservation as economical.

- Finally, the government may find that it is in the interest of the public to incentivize resource conservation efforts, like precision agriculture drones, in order to preserve the environment for future generations.

If any of these factors led to even a few more farmers seeing precision agriculture drones as economical, it could greatly contribute to the widespread adoption of drone technology in precision agriculture.

Although most current research is focused on the assessment ability of drones, a significant amount of research is also aimed at developing drones that can address problems on farms.

- As of now, drones are able to apply fertilizers to specific areas, which can be found with other assessment drones using NDVI for Nitrogen Prescriptions.

- Pesticides can be applied in a similar way to treat infested areas. One research team in Australia even designed a drone to drop “beneficial bugs,” the *Californicus Mite*, on crops to restore an ecosystem that is more favorable to the crop (Turner, T.).

In the future, drones may be able to (1) address irrigation problems without damaging the crops planted above them; (2) pick crops that are ready to harvest, especially in orchards where the harvest time can significantly vary from tree to tree; and (3) seed a field with...
several different crops based on an internal map of nutrient levels, known as polyculture seeding.

Current regulations prevent farmers from operating drones on a regular basis, and as long as farmers have to network through a third party, applications of the drones will be limited to situations in which the drone is only needed a few times a year. Because of this, it will be difficult to address certain areas of the field that didn’t present problems the last time the company that provides the drone service was there. It seems more practical for farmers to just apply fertilizers and chemicals to the whole field instead of treating problem areas.

However, in cases where farmers can’t take machinery out into the field because crops would get damaged, using drones is more time efficient than walking across a field applying fertilizers, pesticides, and water by hand.

As technology advances, future drones may be able to assess problems and address them at the same time. For example, a drone may be able to identify which nutrients are lacking in soil, and address them immediately with fertilizer. This, for now though, is a long ways off.

References


Construction, Automation, Satisfaction

With the constant improvement of camera and video technology, it should come as no surprise that companies are attaching them to drones. Videography companies are no longer the only ones using drones for camera purposes, Construction companies are also transitioning into using drones during daily operations. The overhead view is an invaluable resource.

Drone Company Kespry has been partnering with construction companies, offering the new technology to further advance the construction industry. Offering multiple services to these companies, Kespry and similar companies can revolutionize the construction business. Not only does Kespry offer aerial photography, they offer both 2D and 3D mapping and models. (Kespry, 2015) The advantage to this is a better assessment of progress and the physical state of the construction site. Being able to quickly assess and adapt can put one company over another, and drones used in the business can quickly be integrated into construction workflow.

One advancement that could help drone technology in construction is the automation of the drones themselves. Having the ability to send out drones at the same time every day to take pictures or monitor the progress of a site is a great advantage. Having simple yet functional automated systems is applicable to almost any situation. Alex Stimpson, a researcher at Duke University, is investigating automation in multiple facets. On the topic of drone automation,
he says that the "eventual goal is to make drone autonomous systems so elegant and displays so simple that even the public would be able to control one or multiple drones." (Stimpson, 2015) Having easy to use and highly functional drone systems not only allows for more widespread uses, but also increases certain levels of safety and puts drones in a more positive outlook.

In many cases, construction and industrial sites pose certain dangers to the people working on them. Safety measures such as hard hats and high visibility vests have been almost completely integrated into large scale projects at this time. It is still possible to have injuries and even death on the construction sites even with all of the safety factors. In 2014 alone, 4,679 construction workers lost their lives on construction sites in the US. (OSHA, 2015) Drone technology, especially used in inspections, can reduce those numbers. In windmill construction and inspection, it is incredibly dangerous to scale and inspect the turbine. If a company could eliminate the need for extra people scaling the structure and be able to automatically send a drone to inspect the work being done, less people are around the site which means less people who can get hurt. Aibotix, a drone company, uses it’s Aibot X6 UAV to inspect wind turbines, as it not only lessens the risk, but is also a quick, cheap, and accurate way to inspect the exterior of the turbine. Cutting time down to ten or fifteen minutes, companies can save money and time by also not needing to shut the turbine down. (AIBOTIX, 2016) The sensors on the drone can detect a multitude of different factors of the wind turbine, allowing a complete inspection without risking any lives scaling the structure.

Automation of systems not only affects safety issues, such as on construction sites, but also allows for better data gathering and problem solving. In agricultural applications, swarm drones can monitor crops, apply pesticides, and report any damaged or diseased plants, as well as monitor cattle on open ranges and surveil herds to catch predators. Dedicated,
automated swarms can greatly increase the yield of a product by ensuring the safety of the crop or herd. In both endangered animal

Being able to address problems as soon as they appear will push the perception of drones further along in every industry. Security of properties can be aided by automated drones. Rather than having cameras set up every twenty yards, having drones fly around the perimeter eliminates the need for both stationary cameras and security guards. Along with detection software, the drones could also be able to detect movement in the dark better than the human eye.

Drones have the potential to make industries easier. Through both the action of increasing human safety or automation of inspections, the technology is making its way into most industries.

References


Drones in the Pursuit of Saving Lives

Drone takes Bedford Fire to new heights in search and rescue
(http://www.kaltura.com/index.php/kwidget/wid/1_0sqhxkuq/uiconf_id/16680472)

During search and rescue operations, police and fire departments can utilize drone technology to cover large swaths of land very quickly. Also utilizing beacons and the noise of the rotors, the department can locate the general area of missing persons. One story from Virginia is that a hiker called 911 because she was lost in the Virginian Blue Ridge Mountains, and the fire department, utilizing a newly purchased drone, was able to find her within 3 minutes. After finding her location, it took the rescue team half an hour to hike to the location. With how far away she was, rescue teams could have been searching for hours before they found her. In these search and rescue operations, drones allow fire departments to respond more quickly to situations such as the missing hiker. (Saunders, 2015)

Drones can have many uses in municipal services such as fire departments. They can provide a bird’s eye view of a fire or crime scene with a fraction of the cost of a helicopter crew and with no danger to human life. By employing a UAV at the cost of around two thousand dollars, the risk posed to human life diminishes significantly, putting no lives in the air. This is doubly stated for wildfires. With the rapid air movements and smoke blocking line of sight, a helicopter with a pilot is less feasible than a UAV with special camera equipment locating particularly vital places, such as hot spots or flare ups. Drone technology, especially equipped with the proper sensory technology, can be an invaluable resource to fire departments
around the country. Kaman Aerospace, a helicopter manufacturer, makes the K-MAX, a large unmanned aircraft capable of lifting 27 tons. The investigation into firefighting capabilities has already been started. Kamans Vice President Bob Manaskie says “We can fight fires 24/7, unmanned or optionally manned. That’s the advantage, you can get water on the fires 14 or 15 extra hours per day where a manned system can’t.” (Banse, 2015) The ability to fight fires 24/7 is critical during forest fires, and the unmanned K-MAX will be a critical step towards drone usage in firefighting applications.

For police, drones offer a variation of applications. Similarly to the possible usage in fire departments, police can use UAVs to minimize loss of life. With the correct warrants, drones can aid officers in hostile situations by going where the officer may be in danger. When the dispatcher send out a call which could be dangerous to the officers or individuals involved, they could launch a drone to assess the situation. Giving officers a quick assessment before they even arrive at the call can give the officers better information on how to handle the situation, possibly leading to increased survival rates. Addressing the needs of officers could be a use in the future. Not only can the drone platforms reach officers in the field in a matter of minutes, but they can also be in the field with the officers. In August 2015, North Dakota approved police usage of drones armed with less than lethal weapons. This means that drones equipped with tasers, tear gas, bean bag launchers, and similar less than lethal weapons can be outfitted to UAV technology to prevent danger to officers. (Wagner, 2015)

First responders to emergencies can assess the situation within minutes, before they even arrive at the scene. When a traffic accident happens, ambulances are dispatched to the location of the crash. Depending on traffic, it can take anywhere from ten to twenty minutes for an ambulance to arrive. A UAV can be launched as soon as the call is received and arrive at the location within 5 minutes, faster than any road-bound vehicle. This would allow the drone operator to relay critical information to the responding ambulances for faster response and appropriate medical procedure.

In 2014, Alec Momont, a graduate student at the time, was working on an Ambulance Drone, capable of transporting a defibrillator to a location of a heart attack. Cutting the response
time down from 10 minutes to one can drastically increase the survival rate, he says from eight percent to eighty. (Momont, 2014) Drones with easy to use medical equipment, simple enough to be used with instructions from trained operators, can decrease the amount of time and increase the survivability of emergencies such as the one described in the video.

Drone usage in municipal services that deal with the safety of human life allows for many different heightened aspects of information gathering without sacrificing safety. The gathering of information in hazardous or crowded areas allows for a more accurate assessment and response to any given situation. The loss of human life can be avoided while also heightening the safety measures of various municipal organizations utilizing drone technology.

Municipal entities are not the only groups to use drones to save lives. A civilian outfit volunteers their drones for this very cause. SWARM, Search With Aerial RC Multirotors, uses civilian drones to aid in missing person searches. (SWARM 2014) With skilled civilian pilots and a fleet of sophisticated drones, SWARM can aid in areas where local fire and police departments cannot, due to a lacking of resources. We interviewed Jim Bowers, founder and head of SWARM, about the public opinion of his organization. He said that whenever someone contacts SWARM, they are a bit apprehensive at first, but the technology proves itself when they find missing persons. (Personal Recording, 2015) Search and rescue drones could be the main focus of the municipal services for the years to come, as Fire Departments, Police, and Park Rangers are all constantly involved in said situations.
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Model Aircraft-A New Era of Legal Debate

The FAA introduced new regulation on December 16th, 2015 titled the Registration and Marking Requirements for Small Unmanned Aircraft that requires model aircraft operators to register their model planes before operating them. That regulation is being challenged by Mr. John Taylor because it seem to contradict an earlier act passed by Congress. While the registration helps address some concerns about small unmanned aircraft, it also poses an additional burden to hobbyists.

One model aircraft enthusiast, Mr. John Taylor took issue with the new regulation (Koehler, 2016). According to the lawsuit, the FAA violated section 336 of the FAA Modernization and Reform Act of 2012 which expressly states the FAA “may not promulgate any rule or regulation regarding a model aircraft” (FAA Modernization and Reform, 2012). The FAA published on December 16th, 2015 the Registration and Marking Requirements for Small Unmanned Aircraft in the Federal Register. The interim final rule that requires all unmanned aircraft operators to register with the FAA, if they own or plan to fly aircraft with a weight between 0.55 and 55 lbs.

John Taylor is not the only one who disagrees with the new regulation. The AMA [American Modeling Association] issued a statement for its members to withhold registration until Feb. 19th, the prior owner’s registration deadline. Other hobbyists have rallied to support John Taylor, notably the Drone User Group Network and the DC Area Drone User Group.
The reasoning for his case checks out: the FAA adopted regulation which affects the operation of model aircraft when it was expressly prohibited by Congress. That said, the FAA argues “the prohibition against future rulemaking is not a complete bar on rulemaking and does not exempt model aircraft from complying with existing statutory and regulatory requirements” (80 FR 78634). In short the FAA insists, “Model aircraft are indeed aircraft and thus they are subject to the statutory requirement of aircraft registration” (80 FR 78612). Other means of challenging the Registration and Marking Requirements for Small Unmanned Aircraft are present, and discussed in-depth on the Rupprecht Law website under the title “Drone Law Blog”. As a side note, now that all small UAS-especially those owned by hobbyists, are considered aircraft, other rules, regulation, and law might be applicable.

The regulation may contradict Congress, but the content of the regulation begins to address some of the public’s concerns. Before December 16, 2015, there was no way to identify the owner of a crashed drone. Drones used for nefarious purposes can be captured, and the registration information used to track down the operator. Yes, the operator may remove his/her registration information from the drone but chances are some perpetrators would be held responsible for their actions as a result of this new regulation.

The registration information contained in the drone might help other drone users recover their drones in the event that they are lost, due to a wind gust, breakage or control malfunction. Knowing the FAA registration number would allow the finder of the drone to return it to its owner. The FAA stated, “The general public will be able to search the part 48 registry database by the unique identifier. The name and address associated with that unique identifier will populate in accordance with that search” (80 FR 78632). The FAA also hints that apps may be created to make searching their drone database easy. The registration required by the FAA is very similar to that of the AMA which requires its hobbyists to write their name and address, or identification number on their drones (Academy of Model Aeronautics, 2015).

Registration is easy, it requires the creation of a FAA account using an email address. The account is confirmed, (you have to click a link in an e-mail they send to the registered
account), agree to their privacy policy, then you finish filling out the relevant information (your address, name and phone number), agree that the information provided is correct, agree that you will abide by basic guidelines for operating your drone, input credit card information (there's a $5.00 fee), and you're done. I completed my hobbyist drone registration this morning, it takes about ten minutes. After registering your drone, as a hobbyist, you can start flying, no licenses or training is necessary. You should review the operational guidelines for model aircraft (Model Aircraft Operation, 2016), and it is advisable to start flying as a hobbyist with the company of a knowledgeable friend, they can help prevent potentially expensive crashes, and other unfortunate mishaps.

Finally the regulation creates an easier way for commercial operators to register their drones. Although that element of the bill won't be implemented until March 31, it provides commercial drone operators using drones that weigh less than 55 lbs. a means to more easily register.
References


Drones and Your Privacy

Why should you be concerned about your privacy?

Hobbyist drones are small but they are increasingly being equipped with cameras. Hobbyist grade cameras take pictures/videos with a resolution and quality similar to that of your cellphone, likely worse. Cameras on commercial drone are more impressive, but they are feeble when compared to some of the cameras found on government drones. One particular drone, the A160 Hummingbird, contains a 1.8 gigapixel camera that can “provide real-time video streams at a rate of 10 frames a second”, “track [multiple] people and vehicles from altitudes above 20,000 feet across almost 65 square miles,” even at night (US Army Unveils 1.8 Gigapixel, 2012). The size of the drone roughly corresponds image quality as heavier, larger and heavier equipment is necessary to collect higher quality imagery. Technological advancements may also eventually allow drones to use facial recognition. Hobbyist drones can fly close and low collecting images. Commercial drones might be used to collect higher quality imagery, from equally close and invasive perspectives. Government drones can track your every move in crisp detail as soon as you’re in sight.

Why not the FAA?

The FAA is a regulating body which is given authority to develop rules and regulations by Congress. Despite their “mission to provide the safest, most efficient aerospace system in the world” (Mission, 2010). “It is not at all clear whether the FAA would have the authority to
regulate privacy as part of the OTAs [Other Transaction Agreement]. Congress did not speak
to this issue in [the FAA Modernization and Reform Act of 2012]” [Integration of Drones Into, 2013]. So far the FAA has chosen not to address drone privacy concerns. The FAA cites the
Presidential Memorandum issued on February 15, 2015, which establishes that “best
practices for privacy, accountability, and transparency issues regarding commercial and
private use of UAS in the NAS [National Air Space]” will be established and addressed by the
National Telecommunications and Information Administration (NTIA) [Registration and
Marking Requirements, 2015].

The Electronic Privacy Information Center (EPIC), has taken issue with the FAA “for failing
to establish privacy rules for commercial drones as mandated by Congress” [EPIC v. FAA, n.d.]. They filed a petition with the D.C Circuit and the resulting suit is still being debated.

Currently, the FAA allows drones to fly in national airspace, whether it be only up to 400 ft.
(as hobbyist drones and most commercial drones) or higher altitudes with proper
authorization. The boundary between national airspace and private property is not exact. A
court case, United States vs. Causby established, “a property owner owns only as much air
space above his property as he can practicably use. And to constitute an actionable trespass,
an intrusion has to be such as to subtract from the owner’s use of the property” [Integration
of Drones Into, 2013]. In short this means drones (and other aircraft) can fly above your
property as long as they do not decrease the property’s value by interfering with the owner’s
use of the property or the localized airspace above it. This suggests that flying drones at a
low altitude over anyone’s property, without consent, could lead to a legal
consequence. Drones flying at higher altitudes, over adjacent land or over public land could
still collect imagery.

So who ensures your privacy?

There is not an abundance of law or regulation that clearly defines the acceptable boundaries
of privacy. Some combination of constitutional amendments, congressional acts, as well as
precedent court cases and state/local legislation combine to provide a foundation for the
boundaries of privacy. Due to the current hodge-podge nature of privacy laws, they are different in every state, and potentially locality. There are broad overarching concepts that set the boundaries for what level of privacy invasion is considered acceptable.

The Fourth Amendment is the ground for all government privacy arguments. No government authority is immune from its reach.

The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized” [The Fourth Amendment].

If your state has a nuisance claim, claims of privacy invasion stand “as long as the flight constitutes a substantial and unreasonable interference with the use and enjoyment of the land” ([Integration of Drones Into, 2013]).

A widely accepted, state privacy law, found in Section 652B of the Restatement (Second) of Torts can be applied to photographs taken by drones. The law states that “One who intentionally intrudes, physically or otherwise, upon the solitude or seclusion of another or his private affairs or concerns, is subject to liability to the other for invasion of his privacy, if the intrusion would be highly offensive to a reasonable person.” Although the law leaves it open for a court to decide what is “highly offensive to reasonable person”, it is clear that invasions of privacy and seclusion are not to be tolerated. Further clarification by courts have concluded “Conducting surveillance of a person while within the confines of his home will constitute an intrusion upon seclusion” ([Integration of Drones Into, 2013]). Courts also determined that no legal consequences could be pressed if the intrusion occurred accidentally.

In some states an additional clause was added requiring that “the intrusion must cause mental suffering, shame, or humiliation” to qualify as an invasion of privacy.
Even outside your home, in public, you do not lose all your right to privacy. Causing harm/fear to a person in public as a result of some type of surveillance is strictly forbidden. Photographs taken at brief moments of extreme embarrassment, especially if they take place on private property may be challenged, as you’re right to privacy does not disappear as soon as you appear in public. Public places like bathrooms, have special protection because you have an expectation of privacy in a public bathroom. ([Integration of Drones Into, 2013](Integration of Drones Into, 2013))

Exceptions aside, photographs taken in public places are typically permissible. Once you are in a public place you are visible to the public. You have no expectation of privacy, because you’re in in a place where anyone is free to walk, take pictures, and to say hello.

It is questionable whether the law would allow a drone to take photographs over a city to permit the tracking of a wide number of subjects. This type of tracking is similar to the placement of a GPS device on a vehicle to track its movements. In United States vs. Jones, it was determined that a warrant was necessary to place a GPS tracking device on a vehicle, otherwise it violated the Fourth Amendment right against unreasonable search. During *United States vs. Davis* (2014), the 11th Circuit Court of Appeals decided that “cell site location information is within the subscriber’s reasonable expectation of privacy. The obtaining of that data without a warrant is a Fourth Amendment violation” ([4th Amendment Victory in Cell, 2014](4th Amendment Victory in Cell, 2014)). Further court cases concerning cell phone locational data are likely, as that “decision” was only made in in November, 2015.

As a whole, most privacy laws allow the victim to determine whether his privacy has been invaded. It is up to the victim to decide whether it is really necessary to pursue legal action against the intruding party. There are no hard lines that define what constitutes an invasion of one’s privacy; few laws create a defined barrier. Most invasions of privacy are relatively benign, so no legal action is taken because it is not worth the trouble. If you have concern about a drone flying near or above your house, it is probably best to have a neighborly conversation with the operator, before attempting to file a privacy lawsuit.
Drones increase the number of ways one's privacy can be invaded. Drones are not the only new technology that challenges historical concepts of privacy. Our increased online presence, whether it be though a computer, drone, car or coffee maker- poses a threat to privacy. Other items like cell phones can sometimes collect large amounts of information about our day to day activities are also a becoming a large part of this privacy debate. Determining the threshold of privacy is a challenge the courts will address in the coming years.

Most notably, the National Telecommunications and Information Administration should publish a report by February 15th 2016 addressing the Presidential Memorandum: Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems on Feb. 15th 2015.

Further reading:

- [Domestic Drones and Privacy: A Primer](https://fas.org/sgp/crs/misc/R43965.pdf)
- [Integration of Drones into Domestic Airspace: Selected Legal Issues](https://www.fas.org/sgp/crs/natsec/R42940.pdf)
- [Crowded Skies: Opportunities and Challenges in an Era of Drones](http://www.reedsmith.com/files/Publication/79fd9c03-b51a-42dc-89e0-b9ac73544129/Presentation/PublicationAttachment/16626f59-fd80-4321-9b96-91356377fe76/CrowdedSkies.pdf)
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Model Aircraft: What to Know

It is relatively easy to legally fly recreational model aircraft, especially when compared to what is required to legally fly a commercial or public UAV.

To be clear, model aircraft, helicopters, multicopters, drones and unmanned aerial vehicles are all aircraft (FAA Modernization and Reform, 2012). Before flying your aircraft it, you must register with the FAA. While flying the aircraft you must operate it safely, within the guidelines outlined by the FAA.

**Registration**

A “model aircraft” is: an unmanned aircraft that is capable of sustained flight in the atmosphere; flown within visual line of sight of the person operating the aircraft; and flown for hobby or recreational purposes” (FAA Modernization and Reform, 2012). The FAA Modernization and Reform Act outlined a narrower qualification for model aircraft operation, which additionally requires models to operate “in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization (CBO)” (Model Aircraft Operating Standards, 2016). (Membership with that CBO is not explicitly required).

Model aircraft under 0.55lbs don’t need to be registered, but they do need to be operated within FAA guidelines (Model Aircraft Operating Standards, 2016).
All model aircraft between 0.55 lbs. and 55 lbs. can be registered with the FAA online (sUAS Registration, 2015). Online registration is easy, it costs $5.00, payable only via credit/debit, an email address, and a physical mailing address. When registration is complete, the registrant is given a registration number. He/she can use that registration number on all his/her model aircraft, as long as they weigh between 0.55 and 55 lbs. The registration number must be visible or otherwise easily accessible without using any tools (UAS How to Label).

Model aircraft over 55 lbs. must register via mail or in person just like a full sized manned aircraft. First form AC 8050-1 must be physically acquired and completed-no faxes, photocopies or otherwise computer generated versions of the form will be accepted. The form requires a notarized statement. A complete description of the model aircraft must be provided, in addition to evidence of ownership, and confirmation that the aircraft is not
registered in another country. A relatively trivial fee of $5.00 is also required (Aircraft Registry, 2016). A registration number will be provided and it must be readily displayed in large lettering on the large unmanned aircraft.

Guidelines

The FAA lists the below as guidelines for flying model aircraft.

- Fly below 400 feet and remain clear of surrounding obstacles
- Keep the aircraft within visual line of sight at all times
- Remain well clear of and do not interfere with manned aircraft operations
- Don’t fly within 5 miles of an airport unless you contact the airport and control tower before flying
- Don’t fly near people or stadiums
- Don’t fly an aircraft that weighs more than 55 lbs.
- Don’t be careless or reckless with your unmanned aircraft – you could be fined for endangering people or other aircraft

**Guidelines for Model Aircraft Operations published by the FAA (https://www.faa.gov/uas/model_aircraft/)

The FAAs list of flight guidelines is comprehensive but not exhaustive. But, it is important to avoid flying in “Prohibited Areas, Special Flight Rule Areas or, the Washington National Capital Region Flight Restricted Zone, without specific authorization” (Model Aircraft Operating Standards, 2016). The FAA also requires “model aircraft operators must comply with any Temporary Flight Restrictions (TFR)” (Model Aircraft Operating Standards, 2016). Joining a modeling club (AMA) or subscribing to a modeling group (Fly RC, Model Aviation) might help modelers be more aware of regulatory changes, flight restrictions, and the best places to fly. Finally it is important while flying within these rules to also obeying local ordinances and to be respectful of neighbors and other people nearby.
References


Public Aircraft Operations

In order for a public agency to fly a drone, the agency must have a registered aircraft, a certified operator and a certificate of authorization (COA). The drone must then follow the procedures outlined in the COA.

“The public aircraft statute exists to free governments from regulation, not to confer a benefit on government entities that is unavailable to civil operators” (UAS Operations by Public, 2014). If you are a public entity, the FAA admits it is easier for you to legally operate your unmanned aircraft, why not take advantage of this opportunity?

Public UAV Registration

Not all publicly operated aircraft are required to register with the FAA. “Only certain foreign aircraft and aircraft of the national defense forces of the United States are eligible to operate unregistered aircraft in the United States, and any such unregistered aircraft must be identified in a way satisfactory to the Administrator”. In particular the registration requirement does “not apply to small unmanned aircraft of the armed forces of the United States” (Operation of Aircraft, 1994).

Exemptions aside, all other Public UAVs must register via mail or in person just like a full sized manned aircraft. First form AC 8050-1 must be physically acquired and completed-no
faxes, photocopies or otherwise computer generated versions of the form will be accepted. The form requires a notarized statement. A complete description of the model aircraft must be provided, in addition to evidence of ownership, and confirmation that the aircraft is not registered in another country. A relatively trivial fee of $5.00 is also required (Registry, 2016). A registration number will be provided and it must be readily displayed, permanently in large lettering on the large unmanned aircraft.

Publically operated aircraft will also soon be able to register online, as a part of the Registration and Marking Requirements for Small Unmanned Aircraft on December 16, 2016. Online registration through CFR 14 part 48 should be available starting March 31, 2016.

**Public Certificate of Authorization**

Public agencies must apply and received a public COA to operate legally in the U.S. A COA is a legal document that outlines the operating procedures, guidelines, and processes as they apply for to a specific of unmanned aircraft, in a specific environment. Not all COAs are the same, each defines a specific and different set of rules that agency must follow when operating the applicable aircraft. (Public Operations, 2015) Examples of Public COAs are available on the FAA website. Browsing the Freedom of Information Act Responses reveals the typical Public COA applications come in a wide range of abilities, and degrees of sophistication. If you plan on applying for a COA I would recommend finding a similar already approved COA and using it as an application template.

The COA will specify level of pilot certification necessary to fly the unmanned aircraft, the times it will be flow, as well as the locations it can be flow in, and the maximum distance the aircraft may ever be from the operator. This is just the beginning, it also describes the incident reporting process, pre-flight inspection, maintenance procedures, and what to do if UAV pilot has lost control of the aircraft.
Public COA applications can be submitted online, they are typically processed in less than 60 days.

**Public Flight Qualifications**

Because the determination whether a flight qualifies as a “public” is made on a flight by flight basis operators of public aircraft have to be careful to always operate their aircraft within public definition.

![Decision Flowchart for Federal, 2014](image)

Understanding whether a flight is public can best be determined by following the flow chart ([Decision Flowchart for Federal, 2014](#)). Researchers who are funded by the state or federal government, and whose research is state or federal property may also be eligible for a COA. Activities “such as national defense, intelligence missions, firefighting, search and rescue, law enforcement (including transport of prisoners, detainees, and illegal aliens),
aeronautical research, or biological or geological resource management” are generally considered eligible to operate UAVs under a public COA. (Title 49 U.S.C. § 40125). Qualifications for Public Aircraft Status)

References


The Likely Future of Commercial Drone Regulation

In the immediate future, small commercially operated drones must operate at relatively low altitudes within the line of sight of its operator. In the more distant future it is likely some commercial unmanned aircraft will be able to fly out of sight, at higher altitudes, with a dedicated operator/pilot. Ultimately, some UAVs will likely fly out of sight, at higher altitudes, without a dedicated operator/pilot.

On February 15, 2015 the FAA published a Notice of Proposed Rulemaking (NPRM) which revealed their current thoughts about the operation small UAVs. Just shy of a year later, on December 16, 2015, the FAA published the Registration and Marking Requirements for Small Unmanned Aircraft (RMRSUA) which addressed some of the elements proposed in the NPRM.

Evidence in the form of the NPRM, blanket commercial certificate of authorization (COA), and the rules and guidelines in the RMRSUA, when combined suggest a general set of rules that commercial operators can probably expect.

In the NPRM, the FAA analyzed the primary levels of authorization, certification and approval a regular manned aircraft must get before it is allowed to fly. Similarly this article will analyze the below categories and how they relate to the drones of the future.
Aircraft Registration

For drone under 55 lbs. RMRSUA provides a means for hobbyists, businesses, and public agencies, to register their drone easily online. “A manufacturer and model name, and serial number must be provided for each [commercial/public] aircraft being registered”, in addition to basic contact information, like an email address, mailing address, and potentially a phone number (Registration and Marking Requirements, 2015). Registration online, via the RMRSUA should be available starting March 31, 2016.

Although not required right now, additional information concerning the drone’s use of its sensory equipment may be required to address privacy concerns. Whether it be by S.635-Drone Aircraft Privacy and Transparency Act of 2015, the National Telecommunications and Information Administration (NTIA) or via the FAA, the businesses/agencies operating the drones will likely have issue a data collection statement specifying:

- The individuals or entities who will have the power to use the drone.
- Whether the unmanned aircraft will collect information or data about individuals or groups and if so how that information will be used, stored, analyzed, destroyed or distributed.
- The impact of that drones operation on the privacy of individuals.
- The steps taken to mitigate impact of the drone, and the data collected.
- An address which complaints, requests, and confirmations of data collection might be sent, answered, verified or challenged.

The FAA requires drones operated at test sites to provide a data collection statement. (Unmanned Aircraft System Test, 2013). Data collection statements are required at FAA drone test sites. Statements about data collection are also required according to proposed
bills and the Presidential Memorandum issued on February 15, 2015. Their presence in regulation, presidential memorandum and FAA test site requirements suggest that it may become a necessary part of commercial drone operation.

**Aircraft Certification Maintenance and Inspection**

The risk posed by the operation of the drone will likely set the strictness of airworthiness certification, and inspection.

All drones being flown under 400 ft which weigh less than 55lbs. do not necessary carry the same level of risk. A drone flying over a cornfield to collect crop data, or disperse herbicides would probably only knock down a couple corn stalks in the event of a malfunction. A drone used in a populated area, and in particular near crowds of people pose an increased risk.

The NPRM, directly states that they FAA found that it is not necessary to require airworthiness certification of smaller drones operated at low altitudes, with a total weight less than 55 lbs. The FAA does require the operator to test all flight control mechanism before takeoff in addition to an inspection to verify the integrity of the aircraft. If the aircraft is known to have any issues, it should not be flown until they are addressed. In large part no airworthiness certification is required because there is minimal damage in the event of any mishap ([Operation and Certification of Small, 2015](#)).

It seems likely that for an aircraft to operate out of line of sight, at any higher altitudes, or over any crowds, the aircraft would require additional airworthiness certification. Because a pilot is not onboard he may be less aware of reduced aircraft performance, a typical warning sign of major control/engine problems. The potential lack of pilot awareness, dependence on aircraft control, and higher flight stakes might justify annual inspections, initial aircraft certification, and repair logs. For drones operated out the pilot’s line of sight, the aircraft would have to contain a system capable of detecting relevant nearby aircraft, and obstacles. Due to the critical nature of that detection/avoidance system, it seems likely certification and periodic system testing would be required.
Pilot Certification and Health

The NPRM states that it does not find it necessary for all smaller UAV pilot to receive the same training as a normal pilot. The FAA proposed “to require that individuals obtain an unmanned aircraft operator certificate with a small UAS rating as a prerequisite to operating a small UAS” (Operation and Certification of Small, 2015). The proposed pilot certification would essentially be an initial knowledge test, with a different recurrent test taken every two years to maintain valid certification. The health and operating ability of the pilot would be in part determined at the time the certificate is granted, and at all other times the pilot would be responsible for determining whether his/her health affected his/her ability to operate a drone safely.

The prime motivation in creating this certification was to verify the operator has the knowledge required to operate a UAV safely. The FAA wants drone operators to understand the decision making process of pilots, to know how to communicate with Air Traffic control, and to be familiar with recent Notices to Airmen (NOTAMs). Having a pilot’s license does not necessarily mean you know enough to safely operate a drone, as the risks, and flying techniques, and flying experience are completely different than that of a manned aircraft.

In the more immediate future, for drones of larger size, that operate at higher altitudes, out of line of sight with a dedicated operator, the operator would likely have to complete a pilot certification in addition to some other training concerning the operation of a drone. The reason for requiring a pilot certification is that many of the elements of flight required to fly a smaller drone become more applicable when operating it at higher altitudes, around other aircraft. In particular the pilot would have to be aware of ambient aircraft traffic, his position in the airspace, and the likely decision making process of the pilots around him/her.

In the more distant future it is possible that a new certification designation might be created for the pilots of unmanned aircraft, however the changing piloting requirements/procedures may also eliminate the need for a dedicated operator.
Permission to Fly in Airspace

Currently small UAS operators have to apply for, and receive a COA (certificate of Authorization) that defines the boundaries that that aircraft/operator can fly in. Shortly after the NPRM was posted the FAA offered a blanket COA to anyone with an approved section 333 exemption that allows operators to fly within a set of defined boundaries [FAA Streamlines UAS COAs, 2015].

Under the new policy, the FAA will grant a Certificate of Waiver or Authorization (COA) for flights at or below 200 feet to any UAS operator with a Section 333 exemption for aircraft that weigh less than 55 pounds, operate during daytime Visual Flight Rules (VFR) conditions, operate within visual line of sight (VLOS) of the pilots, and stay certain distances away from airports or heliports:

- 5 nautical miles (NM) from an airport having an operational control tower; or
- 3 NM from an airport with a published instrument flight procedure, but not an operational tower; or
- 2 NM from an airport without a published instrument flight procedure or an operational tower; or
- 2 NM from a heliport with a published instrument flight procedure

In order for a drone to operate outside Blanket COA, at higher altitudes or other airspace, the operator must apply and receive an additional COA. The allowable “risk” presented by the operation of a certain type of drone varies at different locations. COAs are an easy way to help mitigate that risk while still allowing some drones to fly out of the blanket COA. Due to the likely number of COAs it may be advised for a faster, more streamlined application method to exist for COA application.

Of course, an operator is eligible to fly under the blanket COA he/she must have a section 333 Exemption. Applying to section 333 exemption can be a somewhat lengthy, paperwork intensive process. There is good news, a more official route to legally fly commercial drones may be available, June, 2016, when Michael Whitaker, the Federal Aviation Administration
Deputy Administrator said the rule on Small UAS would likely be ready (FAA: Small UAS Rule,” n.d.).

**Means of Avoiding Collisions and Interacting with Nearby Aircraft**

Avoiding collisions and integrating well with surrounding aircraft is perhaps the most important part of flying a UAV. Manned aircraft are not allowed to fly below 500ft even in sparsely populated areas. In more populated areas aircraft are never supposed to fly below 1000ft. Other aircraft like helicopters, gliders, hang gliders, and powered parachutes might fly under 500-1000ft if such low altitude operation does not pose a hazard. (FAA Guide to Low-Flying, n.d.)

Flying a small drone at altitudes below 400ft generally does not pose very large a threat to other aircraft because few aircraft fly at such altitudes except when they take off and land. Aircraft flying that low are generally there with a purpose, and they might appear there on a regular basis which makes avoiding them easy when flying a small drone within your line of sight. The use of spotters as visual helpers is readily described in the NPRM, and it seems likely this element of small drone operation will remain in effect until small drones can be outfitted with collision avoidance and detection systems, and other safety features.

If aircraft are allowed to fly out of the line of sight of their operator they will need a means to sense oncoming aircraft, as well as obstructions. The current means to detect other aircraft usually takes the form of radar which has not yet been yet developed for smaller drones.

In the future, an abundance of nearby Aircraft data, like the position and velocity, and likely route of nearby aircraft will be available via ADS-B int. The FAA is requiring the installation of ADS-B out on all capable aircraft by January 1, 2020 (Automatic Dependent Surveillance—Broadcast, 2010). This requirement suggests that autonomous aircraft might become possible sometime after Jan. 1st 2020 because the drones can use that data to calculate, and
maintain a safe route. This prediction is in line with those of the Congressional Research Service, and technology of this type is being developed by MITRE, and NASA (Canis, 2015), (Strain, DeGarmo, & Moody, n.d.), (Integrated ADS-B System Enhances, 2014). The systems used to sense nearby aircraft, receive and transmit data, in addition to those used process and control the aircraft would be likely subject to FAA certification and scrutiny.

Online registration for commercial drones under 55 lbs. should be available starting March 31. The process should be easier and faster because it won’t be via mail, and the information required is somewhat less extensive. Drone airworthiness will likely rely on pilot preflight testing and personal inspection. A new pilot designation, and associated test will likely be created as a part of the small UAS rule, but health requirements will likely rely on pilot self-assessment. A blanket COA (or similar flight allowance) will likely remain in effect, but COAs for other operations may still be necessary. Section 333 exemptions might become a thing of the past, as of June, 2016 when the small rule for UAS should be enacted. Small UAS will probably be required to operate within line of sight (with the potential assistance of a spotter). Autonomous out of sight flight if drones is reserved for the future, when ADS-B has been fully implemented on the majority of aircraft.

Further reading:

Unmanned Aircraft Operations: Policy Perspectives and the Regulatory Landscape
(http://uas.usgs.gov/pdf/CRS%20UAS%20Report%20Jan%202016.pdf)

The Future of Unmanned Aircraft Systems Pilot Qualification
(http://commons.erau.edu/cgi/viewcontent.cgi?article=1317&context=jaaer)

Unmanned Aircraft Systems (UAS): Commercial Outlook for a New Industry
(https://www.fas.org/sgp/crs/misc/R44192.pdf)
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Praise and Criticism for the FAA

Maintaining safe airspace, especially as drones became more common, is a task the FAA has completed commendably. The good work they have done well is reflected by the fact there have been no reported drone aircraft collision related fatalities (Smaller Drones Aren’t Major, 2015). The FAA has also done a good job collecting data concerning reports of drone sighting’s, in addition to making some of that data available to the public (FAA Releases Pilot UAS Reports, 2015).

The mere existence of a means by which some unmanned aircraft can be operated is commendable. The FAA does recognize that the operation of small unmanned aircraft presents a lower risk than the operation of a manned aircraft. Consistent with their findings, they reduced the regulatory hurdles a drone has to jump before being legally flown, when compared to the operation of a manned aircraft. By reassessing the risk presented by these smaller aircraft, from the ground up the FAA has demonstrated they are pursuing regulation which will “mitigate risk associated with small UAS operations in a way that would provide an equivalent level of safety to the NAS with the least amount of burden to business and other non-recreational users of even the smallest UAS” (Operation and Certification of Small, 2015). The Notice of Proposed Rulemaking (NPRM) and other more recent regulation suggests that further regulation may be introduced that establishes a more even balance of risk and regulatory burden. In particular, “The FAA emphasizes that it intends to conduct future rulemaking(s) to incorporate into the NAS small UAS operations that pose a greater
level of risk than the operations” addressed in the NPRM (Operation and Certification of Small, 2015).

Citizens are concerned about drones. Hobbyists now have to register and some fear additional regulatory restriction. Commercial interests are required to file considerable paperwork and obtain lengthy/expensive certificates, to be granted relatively limited operational ability. States, counties and municipalities are frustrated because they can’t pass their own drone regulations- in fear of violating the FAAs uniformity of national airspace. Several legal suits have been filed against the FAA pointing out regulatory inconsistencies, and violations of congressional mandate. The unwavering steadfast reputation of the FAA has been contaminated by unaddressed citizen concerns, excessive commercial restriction, stifled municipal ordinance and questionable FAA regulation.

In a poll completed by Saint Leo University 71%, an overwhelming majority of the 1,007 respondents indicated they were concerned or somewhat concerned about the presence of drones being operated in the U.S. The reasoning for their concern varied, 64% of respondents indicated that at least some of their concern was due to drone personal privacy issues. Other common reasons for concern were dangerous interference with airplanes (57.8%), weaponization of domestic drones (56.4%) and government spying (50.7%). An even stronger majority 81.9% agreed that drones should be prohibited from photographing ones backyard, house, and family. (More Than One-Third of Americans, n.d)

Citizens looking to the FAA to address their privacy concerns, are dismissed and told to look to the Presidential Memorandum issued on February 15, 2015, Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use per UAS. The Privacy concerns of the public are arguably within the authority of the FAA as a lawsuit filed by EPIC attempts to argue. Other concerns (like the weaponization of drones) are readily within the FAAs ruling authority. Fears of government spying also don’t fall within the scope of FAA regulation. The usage of drones by public agencies to acquire private information is more a challenge of 4th Amendment rights in an age of ever decreasing
privacy. Concerns about weaponized drones, and interference with other aircraft definitely fall within the regulatory scope of the FAA.

The FAA now requires all hobbyists to register before operating their aircraft (FAA Small Unmanned Aircraft, 2016). Previously little to no regulation applied to model aircraft, and the FAA had merely posted operational guidelines. With the introduction of regulation concerning model aircraft, some modeler’s fear additional regulations will either ban or making flying their model planes more difficult (Fear of Flying: FAA Rule-making, 2014).

The FAA insists, and has established through various precedents, “A navigable airspace free from inconsistent state and local restrictions is essential to the maintenance of a safe and sound air transportation system” (State and Local Regulation, 2015). “Substantial air safety issues are raised when state or local governments attempt to regulate the operation or flight of aircraft. If one or two municipalities’ enacted ordinances regulating UAS in the navigable airspace and a significant number of municipalities followed suit, fractionalized control of the navigable airspace could result” (State and Local Regulation, 2015). So, in summary the FAA has authority to bar municipality rulemaking in some circumstances. This inability to enact some ordinance has contradicted the wishes of some localities.

Several legal suits have been filed against the FAA pointing out regulatory inconsistencies, and violations of congressional mandate. Pirker V.S. FAA demonstrated FAA inconsistency in the definition of aircraft as well as a lack of distinction between commercial and recreational operation for a flight in 2011. Technically speaking, an aircraft is; a “device that is used or intended to be used for flight in the air” (14 C.F.R. § 1.1), however drones at that time were less common, and had never previously been subject to regulated as, or considered aircraft (Busting Myths About the FAA and Unmanned, 2014). In 2012, the FAA Modernization and Reform Act (FMRA) of 2012 laid down a definition of “model aircraft”, and established they were contained within the “aircraft” category. The FMRA particularly specifies model aircraft must be “flown strictly for hobby or recreational use” (FAA Modernization and Reform, 2012). Furthermore it prohibited further regulation concerning model aircraft. Taylor V.S. FAA is a suit concerned by the apparent violation of section 336...
of the FMRA, as the FAA passed the "Drone Registration Requirements, in December, 2016, without a notice and comment period (FAA Sued in Federal, 2016). The inconsistencies which led to these two lawsuits have contributed to declining public belief in the FAA.

The FAA has done a commendable job developing early regulation concerning drones and they have done an excellent job maintaining the safety of airspace. Widespread opinion of the FAA has faltered. Much of the public is concerned about drones, and a considerable part of that concern is rightfully aimed toward the FAA. Some municipalities/cities/localities are bothered by their inability to enact some types of ordinance concerning drones. The regulations created by the FAA seem to directly contradict congressional legislation. While the FAA has performed adequately, a clear set of reasonable, simple rules governing the operation of drones of all types will go a long way in repairing its public image.

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More Than One-Third of Americans Say They’d Like to Have a Drone. (n.d.). Retrieved March 2, 2016, from Saint Leo University Polling Institute website: http://polls.saintleo.edu/more-than-one-third-of-americans-say-theyd-like-to-have-a-drone/


A Community Decision: How Drone Use Will Expand U.S. Farming

In recent years, the advancement of precision agriculture technology using drones has been hindered by a lack of (1) proof that drones can save money on farms and (2) economic pressure/government incentive for farmers to take on the corresponding risks. This article will look at areas of agriculture where these two traditional hindrances are quickly dissolving in order to demonstrate what directions precision agriculture drones may be headed in the future.

Case Study: Holy Guacamole, when will it rain?

Recent summer droughts in California have warranted a 25% government-mandated reduction in urban water consumption and a 25% limit on increases in irrigation water (Tweed 2015). This situation leaves many people resentful towards the agricultural industry, which consumes 80% of the state's water, and also forces farmers to tap into groundwater supplies—a largely unsustainable practice—or to invest in precision agriculture tools to help them manage their water supply (Nagappan 2014). Many farmers whose livelihoods depend on water intensive crops are struggling to cope with these limitations. In one case, an avocado farmer, Tom Selleck (who also happens to be the 70-year-old star of “Blue Bloods” and “Magnum P.I.”) was accused last summer of stealing water
One might ask themselves, why would farmers decide to grow such a water intensive crop in such a drought ridden region? It’s a good question: Avocados are native to subtropical climates where rainfall is abundant, 40-50 inches per year (Allman n.d.), and consume 220 gallons of water per pound of crop (Hoekstra 2008). In drought-ridden California, this means that 74 out of these 220 gallons of water must be provided by irrigation (Philpott 2014). With avocados’ popularity where it is, the pounds of crops and gallons of water will stack up very quickly. According to the U.S. Department of Agriculture [USDA], “avocado production per capita jumped from 1.1 pounds in 1999 to 4.5 pounds in 2011” (Philpott 2014). That is to say, the average American in 2011 ate almost 5 pounds of U.S. grown avocado. Tom Selleck’s Ventura county for example, grows avocados in 40% of its orchards (USDA-ARS 2012) despite being rated at a high risk of drought by the World Resource Institute [WRI]’s Water Risk Atlas (WRI 2015).

Returning to the question of why California, the answer lies in the USDA Plant Hardiness Zones. Due to the heat of its subtropical native climate, avocados only thrive in areas where the average annual extreme minimum temperature is 35-50° F (Allman n.d.), which corresponds to hardiness zones 10 and 11. The water consumption of crops is much easier to regulate on a large scale than its environment’s heat, so only growers in the 10 and 11 hardiness zones can grow the crop. These hardiness zones only correspond to two parts of the country, southern Florida and southern California (USDA-ARS 2012).

Climate is not the only determining factor of where Avocados can grow however: consumer demand, crop diseases, and competition also play important roles. As of now, 90% of the avocados in the country are grown in California (Philpott 2014), where the remaining 10% are grown in Florida. California’s Avocados are primarily grown in a coastal 4 county region from Santa Barbara to San Diego (USDA-ARS 2012), a densely populated region that has an abundance of consumer demand for avocados even in its own backyard.
However, much of this demand rests in the balance of its drought conditions. Avocados consumer demand comes primarily from its use the guacamole dips we know and love so much. However, its application as a dip makes leaves it as a non-essential element in many of the foods that go together with guacamole. And many of the products buyers are restaurants, which have a hard bottom-line. Restaurants are constantly threatening to take the product of their menus if growers cannot meet their bottom line prices (Nagappan 2014).

In this way, many farmers are being forced by limited resources and a volatile economy to look for new ways to make their growing operations more efficient. As Alex Charles, expert on remote sensing for precision agriculture, puts it, “There is lot of interest from growers in terms of wanting to implement [drone] technology in their growing operations; [...] However, the biggest limiting factor for this technology seems to be cost.” Farmers need to know that drones are a good investment, and when they are looking for the information to make this determination, they look to see what other farmers are doing instead of simply being sold by drone companies. Most farmers “are just waiting for someone they know or one of their neighbors to start implementing the technology to really see the effectiveness of it before they pull the trigger,” says Charles.

This qualification for the growth of drone use in precision agriculture puts U.S. Avocado growers in a uniquely strong position to facilitate the growth of the technology, as U.S. Avocado growers are so close in proximity to one another (remember the 4 county region in California) that there is a high potential for one farmer’s investment in drones to inspire others. However, in order for one farmer to adopt the technology, its effectiveness must be proved to them.

Precision agriculture drones have many different assessment tools, each designed to provide certain pieces of information about a field, usually in the form of a map. Used in conjunction with one another, these visual techniques have the potential to give farmers a complete perspective of their field:
The most common hardware is visual spectrum hardware. Visual tools can be used for plant counting, which uses Machine Learning algorithms to teach a drone what is a crop and what isn’t.

More sophisticated hardware includes multispectral imaging, which collects data using filters to remove specific wavelengths of light so that they can be indexed during analysis. One such index is the Normalized Difference Vegetation Index (NDVI), which is used to assess plant health and water quality.
Many drones also use thermal imaging techniques that measure the amount of heat given off by objects, in this case, the ground. Thermal imaging allows drones to detect how much water is present in soil by variations in soil temperature. This is a good way to identify water sources and spot problems with irrigation systems.

More sophisticated drones are also equipped with LIDAR technology. This technology bounces light from a laser off a target area and measures variations in the reflected signals to gauge the distance of these objects. Because some light from LIDAR will bounce off the canopy, and other light will bounce off the ground, LIDAR is useful for measuring
crop heights and surface variations as well as for making topographical charts for flood mapping.

**Hyperspectral Imaging**

*Analysis of Hyperspectral Image to Show Plant Stress and Deficiencies (Airborne Technologies 2012)*

Currently, the most sophisticated assessment technique is hyperspectral imaging, which can be used to observe a vast array of the electromagnetic spectrum and identify certain “fingerprints” that materials leave behind depending on their composition. This is extremely useful in mineral and surface composition surveys, which can be used to determine whether minerals (like Nitrogen) are abundant, lacking, or sufficient in a field's soil.

Yes, the theory behind these imaging techniques makes sense and the applications seem straightforward, but what farmers are wondering is: Do all these imaging techniques actually help my farm?

The short answer is, we don’t know yet.
Now, many farmers have already adopted precision agriculture drones that estimate crop yield because it has clear implications on a farmer's ability to sell his/her crop come harvest time. However, the extent to which a farm can be better off by using assessment techniques that help conserve and correctly distribute resources is less clear.

In the Midwest, an abundance of pioneering farmers fighting for a competitive edge has resulted in a “rapid adoption” of drone technology to put it in the words of Alex Charles. The yields and revenues of these pioneering farms will provide an abundance of data in future studies and USDA censuses. However, data from farms in the Midwest may not correlate well to different regions with different crops. Charles notes that many studies thus far “have been more or less inconclusive because [the data] depends on the crop you are looking at,” so there is no guarantee that plentiful data will be accurate data. However, once adequate data is available, hesitant farmers will be much better able to gauge the economic benefits precision agriculture drones offer, and they won’t have to rely on the words of companies trying to sell them products. If the benefits do turn out to be as obvious as precision agriculture companies claim they are, a rapid adoption of drone technology on farms may be in the future.
References


Eliminating the Stigma

It is no secret that drones are a product of the military and therefore the word “drones” sends a shiver down the backs of many people. Drones are often identified with being notorious for the lethal activities in the Middle East and other war zones. However, this militarized technology has been modified and enhanced to benefit civilians for numerous non-military applications like Precision Agriculture, Wildlife Research, Mapping, and Emergency Response (to name a few). As the applications of drones – also known as Unmanned Air Vehicles (UAVs) increases, the drone industry grows and hopefully become bigger than the militarized drone section. As of now, regulations and public opinion is limiting this growth due the stigma that clouds this technology. As an engineering student I would like to bring into limelight the positive applications of drones and help the public see the difference drones could make to our world if given a chance.

When Amazon first presented the idea of using drones to deliver packages, a lot of people were exposed to the idea of drones outside of the military. Drawing from the applications in the military like surveillance, the publics became wary with the idea of commercial agencies threatening their privacy with drones (Reardon, M.). Civilians in the United States are more worried about a multi-copter with a camera flying around in the neighborhood than a lethal MQ-9 Reaper. Moreover, the skeptical approaches to this technology reveals a number of failures like crashes and lack of control over the drones etc. which prevent the public from seeing that the benefits still overweigh the risks. Regulation has a particularly interesting
consequence on drone growth because in order to protect the public from fear of drone misuse, regulations must be introduced. However, in order to sustain a friendly environment for commercial use of drones, regulations must be streamlined. The effect of regulations on the drone industry is further analyzed in our articles under the Regulations Category.

Through our research and interviews with people in the drone industry, we have gathered that one of the main reasons the stigma exists is due to the fact that the public remains ignorant of the various applications. During the BP oil spill disaster in the Gulf of Mexico, a drone was used to assess damages safely without endangering human lives. Environmental and forestry services also use drones for collecting research data and for search and rescue. Further details about these applications are available under the Applications category of this website. Moreover, the media plays an important role in the subject. Most news agencies tend to report on the misuse and failure of consumer drones than the benefits, which consequently makes the viewer believe that drones do more harm than good.

The most common group of people who use drones belongs to the hobbyist community. People who are curious about the technology develop and fly drones for their entertainment and enthusiasm. Most hobbyist drones are used for photography and filming – a small multi-copter with a camera. This mainly raises issues about privacy since there is nothing stopping a random hobbyist to unauthorized pictures of neighbors. People are also worried about drones crashing into them or their property. The technological standards are improving to avoid crashes like the Gimball Drone produced by Flyability, a Swiss Company but the fear still exists. Most people are capable of using common sense and flying their drones over large open spaces and avoid doing low passes over neighborhoods. However, there are always those few people who ignore caution and do dangerous things, and sadly these are the ones we hear about.

As the drone industry grows it is important to eliminate this fear for a better assimilation into the society. Bill Reynolds, Chief Operations Officer at Unmanned Systems Incorporated along with others believe that the only way we can get rid of this stigma is through education and publicizing the positive instances of drone operations instead of the negative ones.
(Reynolds, B). On the side of drone operators, basic morals should be followed to avoid people getting hurt. As the old saying goes: 'Guns don’t kill people, the man behind the gun does'. This applies to drones just as much.

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Dreaming Ahead

Our research has provided us with evidence to support the fact that growth in Technology pushes the individual growth of applications to advance levels, and as they grow, new hardware is developed. The hardware allows drones to have greater potential, but this potential cannot be realized until the government and the public is on board. The ultimate goal of the drone industry is to develop intelligent drones that can collect data, assess, and address the issue at hand without human interruption. Even though this stage in the industry is a long ways off, suitable software and hardware are already being developed and tested. However, in order to get there the industry must move in a certain direction and many small changes must take place to convince the lawmakers and the public of their safety and reliability.

Predictions for the drone industry vary greatly. The consulting firm Deloitte predicts that total revenue from nonmilitary drones in the coming years will be between $200 million and $400 million. Longer-term forecasts are more optimistic, estimating commercial drones could become a billion-dollar industry by the 2020s (Lee, P., & Stewart, D.). Colin Snow, CEO and founder of Drone Analyst said the restriction on flying drones beyond the visual line of sight means ambitious projects like Google's Project Wing and Amazon's Prime Air likely won't dominate the market. Based on the types of initiatives that have already been granted exemptions, the consumer drone market and civil drones used for film, video and photography will likely lead the way. Already, these projects account for nearly half of all
FAA approvals so far. But higher margins in engineering, surveying and agriculture are coming to the forefront.

An industry report released by Drone Analyst, noted that investments in drone technology from January 2015 through May 2015 totaled $172 million — more than the total from the previous five years combined. Most of this money came from venture capital investments, but technology companies such as GE, Qualcomm and Intel are also pitching in, convinced that wirelessly connected drones could one day be a part of the Internet of Things, a network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data (Snow, C.).

In addition, the research in swarm technology will further allow drones to function as a system and perhaps mimic the behavior of birds and bees opening the door for more innovative applications. These applications may include micro drones used to help with pollination like the Robobee and perhaps find a solution to the decreasing number of bees in nature.

But regardless of whether the American public is enthusiastic about drones, it seems that little will be able to stand in the way of their widespread adoption. With society’s consent we can further implement drones with the latest and greatest technology toward the overarching goal of creating Artificial Intelligence (AI) drone systems. With the right balance of regulations and enhancement of technology, the development of Artificially Intelligent drones will be accelerated. The advantages of the drone technology is far ahead of any other alternatives, therefore, it is necessary to encourage and support the growth of the industry for us to see remarkable effects on the society.

[Video of Interest Concerning Swarm Technology – A Ted Talk](https://www.ted.com/talks/raffaello_d_andrea_meet_the_dazzling_flying_machines_of_the_future?language=en)
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Alex Charles  
Mr. Charles is an expert on autonomous systems, remote sensing for precision agriculture, user experience design, and UAS policy. He helped us understand the importance of using UAVs in the application of precision agriculture and how this makes it more accessible to farmers looking for a low cost and timeliness collection of data.

Patrick Sherman  
Mr. Sherman is a UAV instructor at FlySafe and the public face of the Roswell Flight Test Crew. As an experienced instructor, he provided us an insight into the importance of certification of drone operators. This would make the technology safer and allow more innovative applications to be born.

Jim Bowers  
Mr. Bowers is an experienced drone pilot and the founder and director of SWARM (Search With Aerial RC Multi-Rotor). We found SWARM to be a very inspiring application as it builds a bridge between the drone industry and the common public in a positive manner. The conversation with Mr. Bowers allowed us to realize the potential of UAVs.
**Todd Van Epps**  
Mr. Todd is the owner of Channel Islands Aerial and has been operating drones for both government agencies and regular individuals for the past 4 years. He is one of the instructors at CI Aerial, where he teaches his student the basic knowledge of drones and the importance of safety with UAV technology.

**Bill Reynolds**  
Mr. Reynolds is the Chief Operating Officer (COO) at Unmanned Systems Incorporation (USI) focused on implementing USI's capabilities into the commercial market. As an independent consultant, Mr. Reynolds is a technical expert in Unmanned Systems for various companies. Also he is a member of the US Air Force Reserve, where he is a senior instructor in sensor operations for UAVs.

**Gene Robinson**  
Mr. Robinson has been known as a highly respected UAV pilot for many years. He has specialized in search and rescue missions with UAVs since 2005. He is currently researching UAV capabilities (Multi-Spectral Imaging/Near Infrared Imaging) in the field of forensic anthropology.

**Sally French**  
Ms. French is a journalist and the blogger whose work has been published in several major news outlets, such as CNN, BBC, Forbes, and the Economist. She is the inspiring mind behind TheDroneGirl.com, a blog that focuses mainly on developments in the hobbyist and commercial fields of drones.

**Daniel B. Schwarzbach**  
Mr. Schwarzbach is the Executive Director and CEO of the Airborne Law Enforcement Association [ALEA] and has been working for the Houston Police Department for 35 years. He has a military background, which has helped him in both endeavors. Most recently, as ALEA president, he revived the Airborne Law Enforcement Accreditation Commission and secured funding to develop an accreditation process to support successful drone practices.

**James Betenbough**  
Mr. Betenbough is a young enthusiastic entrepreneur, and owner of a budding business Texas Aerial Solutions. Mr. Betenbough helped us understand some of the challenges, applications and market potential present in the drone industry.

**Jonathan Rupprecht**  
Mr. Rupprecht is a lawyer who has dedicated his practice to UAS regulation and law. He also provided in depth insight into the regulations concerning drones. Our conversations with him helped us understand the FAA regulation released on December 16th and how it conflicts with the FAA Modernization and Reform Act of 2012.
**Mike Kass**
Mr. Kass is a senior engineer in the Fuels and Engines Research Group at Oak Ridge National Laboratory. In addition to 15 years of experience in dynamometer testing, emissions, engine materials and alternative fuels, he recently established a high speed engine testing facility. Mr. Kass provided in depth knowledge concerning the future of small internal combustion engines and their usage on small UAS. His conversation helped us realize the deficiencies of battery technology, and the likely future of small drone engines.

**Ty Audronis**
Owner of Audronis Media, Mr. Audronis is a professional multicopter pilot, having worked with Discovery, the Travel Channel, and the Sci channel among other larger television channels. Largely a videographer, Ty is concerned with the limitations on commercial drone use in the US. We talked with Ty to gain an in-industry perspective early on.

**Roger Matus**
Roger Matus is the COO of Neurala Inc. in Boston, MA. Primarily working on the software interface between drones and control platforms. Mr. Matus talked to us about technology and the commercial applications, as well as offered an international perspective.

**Alex Stimpson**
Currently a postdoctoral associate at Duke University, Alex researches the technology behind automated systems on drones, investigating levels of automation for different situations. We talked to Mr. Stimpson about his knowledge and research into automation and how that technology could be applied to drones.
INTRODUCTION

Start

Jamie: Good evening everyone. Welcome to our IQP Presentation about the impacts of non-militarized drones on society. My name is Jamie Donahue and I am here tonight with my four team members...

Nicholas Borowski;
Alex Brown;
Alexander Korza;
and Lumbini Parnas;

Introduction

Jamie: Our project explores the relationship between technological growth and the impact of drones. We did this by analyzing the interaction of drone capability, public opinion and regulation in a wide variety of applications.

Jamie: We conducted 15 interviews with a range of drone experts in the U.S., each of which specialize in a particular area of the drone industry. The opinions, experiences, and knowledge these lawyers, UAV pilots, and manufactures shared, in addition to existing literature, helped us evaluate the current and likely future of drone usage as well as anti-drone technology.

Alex B: We created an infographic that synthesizes our research, which we will use to explore the status of drones being used in Mapping & Imaging, Precision Agriculture, Wildlife Research, and Emergency response.

DIAGRAM

Korza: The infographic visualizes the relationship between technological advancement and a drones impact on society. In the most direct sense, advances in technology will give
drones more tools to operate with. However, the utilization of these tools depends highly on regulation and public opinion.

**Alex B:** Because public opinion varies by where the drones are being used, how they are used, by whom and regulation, we divided the operational ability of drones into four different categories: Prototype, Assess, Address, and Automation-Artificial Intelligence. Each category represents a more complex level of operation.

**Korza:** The Prototype category, represents the establishment of a platform. Individuals and companies experimenting with fixed-wing or multicopter drones for use in new applications fall into this category.

**Alex B:** The Assessment Category means that drones are being used to collect data, using sensors attached to the platform. Drones taking pictures, generating 3-d maps, or thermal imagery fall into this category.

**Korza:** Address means that a physical task is completed by the flying platform. A drone that collects soil samples, sprays pesticides, or delivers packages falls into this category.

**Alex B:** Automation-Artificial Intelligence is a largely futuristic category where a drone platform processes the information collected by its sensors to make decisions (without human intervention) and address issues on its own.

**Korza:** Technology pushes the individual growth of these categories, and as they grow, new hardware is developed. The hardware allows drones to have greater potential, but this potential cannot be realized until the government and the public is on board.

The length of the scroll measures the success of regulations.

The number of green people represents support from the public.

Being able to visualize the interrelationships between technology, regulation, and acceptance comes down to two basic questions:

To what extent is the technology there?
How much are they, the government and public, on board?

**Alex B:** These are important questions that must be considered when analyzing a drones impact on our way of life. We will start this analysis of drone applications in Precision Agriculture.

**PRECISION AGRICULTURE**

**Prototyping:**

**Korza:** Precision agriculture is defined as a farming management concept based on observing, measuring, and responding to inter and intra-field variability in crops. **Intercrop variability** refers to crops in specific areas of a field doing better than others.
Intra-field variability refers to certain fields (usually of a specific crop type) doing better than others. Drones can be used to collect information about and address in-field issues, which helps crops grow at optimal rates.

There are 2 types of drone platforms: multicopter and fixed-wing drones. The advantages of fixed wing drones are that they can cover large areas in relatively few battery cycles. The advantage of a multicopter drones is good stability for visual and assessment tools.

Alex B:

Currently, the FAA requires commercial drone operators to a. Have a Section 333 exemption, b. Certificate of Authorization c. **Pilot’s license** d. As well as a Registered unmanned aircraft

These Licenses, Exemptions, Authorizations, and Registration can be applied for, through the FAA. Getting a pilot’s license is a significant investment of time and money, and much of the knowledge gained is not particularly applicable to piloting a drone, let alone farming. Applying for each authorization/registration/exemption is a time consumer, paperwork intensive task. Many of the subject we interviewed were upset by the current system commercial drones were being regulated by. The reason for their outrage was not only from the time consuming, and complicated paperwork, but also the limited operational ability they were granted, as most commercial drones have to be under 55 lbs, operated within line of sight at relatively low altitudes.

Air traffic control may have to be notified of their operation.

But there’s good news, the FAA is making progress on new regulation which should make it easier for drones under 55 lbs to be operated within line of sight, for commercial purposes. Some aspects of this new regulation, namely online aircraft registration should be active/available starting March 31st of this year.

Korza: Of these regulations, the most difficult for farmers to tackle is getting the pilot’s license needed to fly drones commercially. Because the vast majority of farmers don’t have or want this license, right now, even if a farmer is interested in using drones—he/she will most likely have to reach out to companies that provide precision agriculture drones as a service. This limits how much farmers are willing to use drones because they need to pay and coordinate with a third party to get images of their fields.

Although regulations can hold back drone use, their integration into precision agriculture depends even more on the drone’s assessment hardware:

**Visual/Multispectral**

Nick: The most common hardware is visual spectrum hardware:
• Visual tools can be used for **plant counting**, which uses **Machine Learning algorithms** to teach a drone what is a **crop and what isn't**.
• More sophisticated hardware includes **multispectral imaging**, which collects data using filters that capture specific wavelengths of light both in and out of the visual spectrum.
• Multispectral imaging uses various **vegetation index calculations**, like NDVI, the Normalized Difference Vegetation Index, to assess **plant health and water quality**.
Vegetation Indices are simple graphical indicators used to analyze remote sensing measurements.

**Thermal Imaging**

**Korza:** Many drones also use **thermal** imaging techniques that measure the amount of heat given off by objects, in this case, the ground.
• Thermal imaging allows drones to detect how much water is present in soil by **variations in soil temperature**. This is a good way to **identify water sources** and spot problems with irrigation systems.

**LIDAR**

**Jamie:** More sophisticated and expensive drones are also equipped with **LIDAR** technology. This technology bounces light from a laser off a target area and measures variations in the reflected signals to gauge the distance of these objects.
• Because some light from Lidar will bounce off the canopy, and other light will bounce off the ground, Lidar is useful in measuring the **height** as well as **surface variation** in crops.
• Measurements in surface variation can lead to the detection of problems like **laurel wilt disease**, which is currently having adverse effects on Avocado growth in Southern Florida.
(http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4415916/)
• Lidar is also useful in making topographical charts for **flood mapping**.

**Hyperspectral Imaging**

**Lumbini:** Currently, the most sophisticated assessment technique is **hyperspectral imaging**, which can be used to observe a vast array of the electromagnetic spectrum and identify certain “fingerprints” that materials leave behind depending on their composition.
• This is extremely useful in **mineral and surface composition surveys**, which can be used to determine whether minerals (like Nitrogen) are abundant, lacking, or sufficient in a field’s soil.

**Acceptance**

**Korza:** We have just described how several assessment techniques work, but what farmers are wondering is: Do all these imaging techniques actually help my farm?

• Now, many farmers have already adopted precision agriculture drones that estimate crop yield because it has clear implications on a farmer’s ability to sell his/her crop come harvest time. However, the extent to which a farm can be better off by using assessment techniques that help conserve and correctly distribute resources is less clear. To some, research in this area feels like a pseudo science; most studies
conducted on this topic have largely been inconclusive. There are simply too many variables, the most significant of which being crop type. Vegetation indices are especially susceptible to crop type; although as it stands, these indices are supposed to be universal. NDVI, for example, has been inconsistent for both corn and cotton.

Jamie: Farmers need hard proof that the technology is economical before they can implement it. In the Midwest, an abundance of pioneering farmers fighting for a competitive edge has resulted in a rapid adoption of drone technology. The yields and revenues of these pioneering farms will provide an abundance of data in future studies and censuses. Once adequate data is available, hesitant farmers will be much better able to gauge the economic benefits precision agriculture drones offer, and they won’t have to rely on inconclusive studies and companies trying to make a buck.

Lumbini: This rapid adoption, however, tends to occur on a regional scale. Farmers are influenced much more by what their neighbors are doing than what research says. This means that adoption of drone technology will often be confined by geography and accelerated by the density of farmers who are growing the same crop.

Nick: The rapid adoption is also accelerated by scarcity of resources and economic pressure. One of the reasons why precision agriculture drones are taking off so quickly in the Midwest is because much of the water access in the Midwest is based on a depleting ground water reserve. In areas with heavy competition, the adoption is accelerated even further: farmers who need to find a competitive edge to survive are more willing to take risks on new technologies than farmers who are in more steady and less competitive markets.

Korza: There are several factors that might accelerate this adoption in the future:
- The most inevitable of these changes is that technology will improve; If researchers can improve the consistency of vegetation indices to account for variations by crop, farmers wouldn’t have to be so hesitant about adopting the technology.
- Another virtual guarantee is that the market and economy will be subject to change: economic woes and increased competition may put more farmers in a position where they have to take risks, like investing in drone technology, to survive.
- The adoption of this technology might also be driven by necessity: depleting resources might force farmers to accept resource conservation as economical.
- Finally, the government may find that it is in the interest of the public to incentivize resource conservation efforts, like precision agriculture drones, in order to preserve the environment for future generations.

If any of these factors led to even a few more farmers seeing precision agriculture drones as economical, it could greatly contribute to the widespread adoption of drone technology in precision agriculture.

Address:
**Lumbini:** Although most current research is focused on the assessment ability of drones, a significant amount of research is also aimed at developing drones that can address problems on farms.

- As of now, drones are able to apply fertilizers to specific areas, which can be found with other assessment drones using NDVI for Nitrogen Prescriptions.
- Pesticides can be applied in a similar way to treat infested areas. One research team in Australia even designed a drone to drop “beneficial bugs,” the *Californicus Mite,* on crops to restore an ecosystem that is more favorable to the crop. ([http://www.goodnewsnetwork.org/drone-natural-pest-control-australia-2015/](http://www.goodnewsnetwork.org/drone-natural-pest-control-australia-2015/))

**Korza:** In the future, drones may be able to (1) address irrigation problems without damaging the crops planted above them; (2) pick crops that are ready to harvest, especially in orchards where the harvest time can significantly vary from tree to tree; and (3) seed a field with several different crops based on an internal map of nutrient levels, known as polycultural seeding.

**Regulation**

- Current regulations prevent farmers from operating drones on a regular basis, and as long as farmers have to network through a third party, applications of the drones will be limited to situations in which the drone is only needed a few times a year.
- Because of this, it will be difficult to address certain areas of the field that didn’t present problems the last time the company that provides the drone service was there.

**Acceptance**

- Because of this, it seems more practical for farmers to just apply fertilizers and chemicals to the whole field instead of treating problem areas.
- However, in cases where farmers can’t take machinery out into the field because crops would get damaged, using drones is more time efficient than walking across a field applying fertilizers, pesticides, and water by hand.

**Processing AI:**

As technology advances, future drones may be able to assess problems and address them at the same time. For example, a drone may be able to identify which nutrients are lacking in soil, and address them immediately with fertilizer. This, for now though, is a long ways off.

**MAPPING**

**Nick:** Being able to test different factors of crops quickly is advantageous to farmers, and drone technology can help them do that. The technology that we talked about can also be applied to mapping the physical world. Equipped with both visual spectrum and Lidar cameras, a drone can survey an area quickly and efficiently, creating maps in both 2 and 3 dimensions.

There are many ways to create maps using the drone platforms available. Visual spectrum cameras allow for photos or videos to be taken as the drone flies over a landscape or building. These can be assembled to create large area maps, giving an accurate picture of
the current situation. Lidar cameras can be used to create point maps, which is a 3 dimensional map of a location. This registers a set of data for that one point. Using the camera over an area creates a set of points including their location, and inputting the points into a computer program allows a 3 dimensional map to be created. The image shown on screen is actually a point map of a school building. This technology is being used to map landscape elevation, monument structure, and building operations. Drone companies like Kespry are using their technology to map construction and mining sites, giving quick, accurate images about the construction zone.

**Alex B:** One of the concerns raised by drones taking photographs and creating maps is privacy. In a poll of 1007 people, conducted by Saint Leo University, 74% of respondents expressed concern about drones. 64% of respondents then cited privacy as the reason for their concern. Little regulation has been introduced that protects us, civilians from being spied upon by drones. In most instances, an individual who feels their privacy has been violated must prove that substantial injury, harm or damage resulted.

In instances where the drone is being operated by a member of law enforcement additional regulation may apply. Using a drone to collect information that would have otherwise necessitated a warrant, is generally considered a violation of the law. Using a drone to track an individual might be similar to the use of a GPS tracker, or the acquisition of cell phone location data. Placing a GPS tracker on a suspect requires a warrant: whether the acquisition of cell phone data requires a warrant is a subject of a Supreme Court case, *United States V.S. Graham*.

It is likely additional legislation/regulation will be released that will address drone privacy concerns. The Presidential Memorandum: Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems issued on February 15, 2015 by Barack Obama ordered the National Telecommunication and Information Administration to begin developing drone privacy regulation.

**Nick:**
Drones also have applications in the film industry. They have already replaced helicopters and large contraptions for aerial shots. The advantages of a drone over helicopters is that they are more stable, can be operated from the ground, disturb the set less, and are more easily obtained and more cost effective.

For real estate purposes, drones can be used to take aerial photos of buildings and houses, you don’t have to hire a helicopter or plane to take photos. You can also create 3d models of houses for sale. Insurance companies can use drones to take better inspections without physically climbing the building.

**WILDLIFE RESEARCH**

**Introduction**

**Lumbini:** Mapping information can also be used to improve the quality of lives for animals in the wilderness. Living in Kenya has fueled my passion for wildlife and it breaks my heart to see that during the past few years, poaching activity has increased an alarming level
around the world. From Tigers of Thailand to the Elephants of Kenya. One of the critical cases, is the pursuit of the South African Rhino where every day 3 Rhinos are hunted down for their horns. 400 rangers of the Kruger Game reserve find it difficult to handle the situation and is impossible to control an area of almost 20,000 square km.

**Counter Poaching**

**Lumbini:** In 2014 the Wildlife Conservation UAV Challenge was introduced to foster the innovation and utilization of UAVs to assist with counter poaching and illicit wildlife trafficking. One of the entries to this competition was the Ranger Drone Project from the HEMAV (Hey-Mav) Academics team which addresses the poaching epidemic in South Africa. This provides the National Park staff with the tool to broaden their surveillance capacity. A fleet of autonomous UAVs (cameras and sensors including) gives the Rangers a bird’s eye view and real time information. The ground station for these UAVs is mobile and consists of a laptop, GPS, and communication system. Meanwhile, the UAVs utilize 3G for long distance communication with both the ground station and other units. Each drone can be assigned a certain airspace to patrol over and can consistently provide feedback to the rangers. Furthermore, infrared cameras allow the UAVs to be used at night. This tool helps the rangers detect poachers before they get to the animals. Sensors on board the UAV can (1) detect the weapons the poachers are carrying, (2) estimate the proximity to the animals, and (3) provide the best route that the rangers can take to stop and capture the poachers.

**Sea Lion Population in Alaska**

**Jamie:** The Ranger Drone Project is one out of the numerous examples. Researchers have pushed the limits of these UAVs by operating them in the rough weather conditions and have emerged with stellar results. The Scientists from the University of Alaska Fairbanks along with NOAA’s National Marine Mammal Laboratory conducted a population study on Sea Lions in the Alaskan, Aleutian Islands. With winds up to 30 knots, precipitation, and swells over 10 feet, a single Aeryon Scout Micro UAV was flown for 6 hours with 31 flights. The scout captured over 60 gigabytes of data, which were then used to accurately determine the sea lion population including their gender and approximate age. Data of this quality would simply be impossible to be collected on foot or by a ship encircling the islands.

**Whale Research**

**Nick:** Expanding this horizon to the marine life, Ocean Alliance in collaboration with Olin College are developing a technology that proves that you don’t have to kill a whale to learn about whales. Snotbots, which are small and cheap drones can be launched by researchers from the boat as soon as a whale is spotted. The drone equipped with sponges can fly over the whale and collect the blow which is basically snot – mucus and lung lining and all sorts of good stuff that tell the scientists about stress hormones, DNA, toxins and diseases in the whale. These drones allow the data to be collected without hurting the whale and without them knowing.
This entire package can be produced for about 2850$ including cameras which transmit First Person View to the pilot. The whale surveys that are being done today use airplanes that fly low and slow, so they are expensive and extremely dangerous. Once people realize what drones are capable of at this affordable price it could open a tsunami of opportunities for scientists.

**Negative Effects of Drones on the Wildlife**

**Alex B:** That being said, drone use for wildlife research may have a downside. Drones can seriously stress out wild animals even if they are not showing it. A study from the University of Minnesota describes researchers terrifying some black bears for the sake of Science. They flew a small quadcopter over 4 wild bears that were equipped with heart rate monitors and GPS trackers. The drone never got closer than 46 yards to the bears, but they panicked anyway. Even though they didn't act frightened the heart rate monitors recorded huge jumps every time the drone came near.

This study supports the concerns of the National Park Service which banned the use of private drones within the parks due to noise, frequent crashes and the concern that they may be affecting wildlife. Despite this, they permit some drones to be operated as a part of research, firefighting, and search and rescue.

The researchers are likely to conclude that the benefits still outweigh the risks. Even if the average quadcopter sounds like the world's angriest swarm of bees it is still bound to be less stressful than being circled by a full size helicopter.

**Potential Future**

**Lumbini:** Like earlier mentioned applications, Wildlife research also depends on the ability of a drone to assess an area and collect the required data. Moving onto the next stage of this technology researchers like Dr. Thomas Trappenberg at Dalhousie University focuses on augmenting these research drones to autonomously fly around and make decisions. One example would be automatically tracking the research ship’s location, finding the path back and landing on the deck without any human assistance. This simple task requires the drone to be equipped with algorithms to help them anticipate the motion of the ship on rough waters and adjust accordingly.

The development of improved technology will most probably result in quieter rotors and anti-crash systems, making the use of drones in wildlife research more prominent. This would ultimately help us study and save the wildlife in their natural habitat.

**EMERGENCY RESPONSE**

**Nick:** Drones can not only be used keep track of and save endangered animals, but they can also be used to find and save endangered humans. During search and rescue operations, police and fire departments can utilize the technology to cover large swaths of land very quickly. Also utilizing beacons and the noise of the rotors, the department can locate the general area of missing persons. One story from Virginia is that a hiker called 911 because she was lost, and the fire department, utilizing a newly purchased drone, was able to find her within 3 minutes. After finding her location, it took the rescue team half an hour to hike
to the location. With how far away she was, rescue teams could have been searching for hours before they found her.

A civilian outfit volunteers their drones for this very cause. SWARM, Search With Aerial RC Multirotors, uses civilian drones to aid in missing person searches. With skilled civilian pilots and a fleet of sophisticated drones, SWARM can aid in areas where local fire and police departments cannot, due to a lacking of resources. We interviewed Jim Bowers, founder and head of SWARM, about the public opinion of his organization. He said that whenever someone contacts SWARM, they are a bit apprehensive at first, but the technology proves itself when they find missing persons.

The platforms currently involved in emergency response are limited, as most departments do not have the extra funding to purchase the technology. Being a public organization, the regulations surrounding emergency services are different from the private or commercial operations.

**Alex B:** Regulation largely allows public operators to fly their aircraft however they see fit as long as it is within the bounds of their Certificate of Authorization - COA. Typically public agencies are given more operational leeway when compared to commercial flights. I was talking with a public agency at the career fair, they shared a story about the use of a drone to monitor water flow in everglades, which they did while flying the drone out of line of sight. Out of line of sight operation of drones is unheard of for commercial agencies, and is only allowed at the drone test sites. Applying for a COA for a public agency requires the completion of an online application, drone registration, and testament for the “public” nature of the drones operation.

**Lumbini:** In a poll of about 1700 people completed by the University of Monmouth, 80% of respondents supported the idea of drones being used in search and rescue. Roughly 65% also supported the idea of drones being used to track criminals and control illegal immigration. 80% of respondents expressed some concern about the use of drones by law enforcement. The wide spread of opinion demonstrates that the public acknowledges the usefulness of drones, but also fears of how they will be utilized.

**Nick:** The ability to assess situations quickly would be invaluable to law enforcement. When the dispatcher send out a call which could be dangerous to the officers or individuals involved, they could launch a drone to assess the situation. Giving officers a quick assessment before they even arrive at the call can give the officers better information on how to handle the situation, possibly leading to increased survival rates. Addressing the needs of officers could be a use in the future. Not only can the drone platforms reach officers in the field in a matter of minutes, but they can also be in the field with the officers.

Similarly, drones could be used in firefighting applications. Flying a helicopter during a forest is incredibly dangerous. Having the maneuverability of a helicopter and lacking the on board pilot, drones are a much safer option. Camera technology can locate hotspots in wildfire situations, even without on board camera operators, yet again improving on helicopter pilots. In 2014, blast mats at a quarry in Connecticut caught fire near a storage
site of mining grade dynamite. Being unable to judge the distance from the fire to the storage locker, the firefighters utilized a drone to fly in and estimate if it was safe to fight the quarry fire. Drones are able to fly within areas where it is unsafe for humans to go, much like military bomb disposal robots. Keeping firefighters safe is a never ending industry, and drones are a key technology to keep firefighters safe.

**Korza:** EMTs, or emergency medical technicians, are trained to respond immediately to a situation where a person needs medical assistance. Ambulance crews are expected to arrive in less than fifteen minutes of the call, but sometimes they cannot get there in time. To fill this need, drone technology has been adapted to reach the location in under a minute, providing emergency medical needs. An ambulance drone, outfitted with a defibrillator, was developed at Delft University of Technology in the Netherlands. Lightweight and collapsible, this drone is equipped with the technology to stabilize heart-attack patients. Alec Momont, the creator of this ambulance drone, says that this cut in response time increases the survivability of heart attack patients from 8 to 80 percent. The use of drones can not only help find people in trouble, but also actively be a part of helping those who are in trouble.

**ANTI-DRONE**

*Introduction*

**Jamie:** After seeing the many applications that drones can be used for, you must be wondering: well if they are so great then why aren’t we using them more. The answer to that is actually pretty simple and maybe even a little disappointing, *fear.*

Turn on the news: Are you going to hear more about drones improving crop yield or a drone landing in the White House lawn? The misuse of drones tends to get a lot of media attention. And sometimes for good reason:

In April 2013 a mexican drone was caught smuggling 28 lbs. of heroin across the U.S.-Mexico border. And in April of 2015, A small drone with traces of radioactive material landed on the roof of the Japanese prime minister’s office.

**Korza:** As stated before, in order to successfully implement a technology, the government and the public must be on board. The government has provided a set of guidelines for people to use drones, but these regulations can do little to stop people who are intent on misusing drone technology. To address these misusers as well as the fears of the public, certain anti-drone technologies have been introduced. Anti-Drone technology is defined as technology made specifically to stop drones from being misused.

*Prototyping*

**Jamie:** With Anti-Drone technology being fairly new, prototyping is where most of the research is currently taking place. DJI, the best-selling small drone manufacturer based in Shenzhen (Shen-chen) China, embeds a no-fly-zone feature into the drone’s GPS software
that prevents them from entering unauthorized areas, like those near airports. When the drone is about to enter a restricted space the drone will send a warning back to the operator. If the operator ignores it, the software prevents the drone from continuing onward. It is basically like flying into an invisible wall.

**Korza:** In Japan, Tokyo Police are using their own interceptor drone to catch unauthorized drones with a large net hanging below their police drone. After entangling the offending drone, it can be gently carried to the ground.

Even the Dutch police has come up with their own method to capture out-of-control drones. They have teamed up with Guard From Above, a raptor-training security firm based in The Hague (Hey-guh), and are currently training eagles to take them out of the sky.

**Jamie:** However there are more aggressive ways to deal with drones. Such as simply shooting it out of the sky with a shotgun or with a laser. Or even hacking into a drone system to take control of it. This can be a good thing or a bad thing depending on intentions. If you plan to safely maneuver the drone to the ground or you plan to use it as a weapon.

**Alex B:** If you want to develop/own an anti-drone system, have no fear: Few laws forbid owning devices capable of tracking, disabling, or otherwise controlling drones, as long as the components are not like a gun that falling into a “controlled” category like firearms.

**Assessment**

**Jamie:** Before Anti-Drone Technology can be effective, we need to be able to identify drones flying in restricted airspace. Although fairly new, the company known as Anti-Drone Systems has developed its own “Anti-Drone.” Minus the super cool name, this Anti-Drone is a sophisticated border protection system that detects UAV intrusions, transmits warnings, and neutralizes them. The key component to the “Anti-Drone” system is the Harrier surveillance radar, made by the company, Detect.

**Jamie:** On the other hand, NASA is researching technology to create an air traffic system that could track small, low altitude drones. According to NASA’s Safe Autonomous Systems Operations manager, Parimal Kopardekar, NASA wants to create a system that can keep track of drones and deliver critical information to the operators via the UAV, such as areas that are unauthorized or if there are other air vehicles in the same airspace. Currently, the NASA team is exploring and testing ways to communicate this data to the UAV during flight, such as geo-fencing and virtual barriers, which will transmit the most updated real-time information to the UAV. As of now, NASA envisions two types UAV Traffic Management systems (UTM):

1. A portable system to monitor operations, it can move to various geographic locations
2. A persistent UTM system that would give continuous coverage of low flying drones in particular locations.
NASA has also decided to explore tracking low-altitude drones with cell phone towers. It is still in the early stages, but the idea behind it is that the system would monitor drone activity across the Verizon cellular network through the sensing equipment on board the aircraft.

**Alex B:** No laws prevent you from “assessing” airspace; however there are certain locations, namely near military installations, or restricted airspace where tracking or identifying aircraft may cause trouble. Depending on the type of system used, it may fall under Federal Communication Commission (FCC) regulation. Basically, any system that involves electromagnetic waves (like radar) is the FCC’s business.

**Addressing**

**Jamie:** Once the technology for drone identification is created and successfully tested, we can start applying anti-drone technology to situations where drones are being misused, like unauthorized drone flight near airports. Regulatory agencies around the world are worried that a drone could hit a plane and cause serious damage that could result in many deaths. But let’s say we apply DJI’s “Invisible Wall” software, we can then prohibit drones from entering unauthorized airspace and basically resolve the problem in one sweep if all drones were required to have this type of software installed.

So you might be wondering, why are we inventing all these cool things to take down drones when we can just use guns! Well apparently the law doesn’t agree with this method.

**Alex B:** All drones are considered aircraft. Depending on the method used to disable the drone, different regulations may apply. Generally tampering with an aircraft, or its control system should not be undertaken unless authorized, as implied by Title 18 U.S.C. Section 32: Destruction of aircraft or aircraft facilities, the penalty of tampering with aircraft is very serious.

**Jamie:** Anti-drone technology will create a peace of mind for most individuals and hopefully influence them to support drone advancement. Knowing that if something goes wrong— whether it be intentionally or unintentionally—anti-drone technology will be there to prevent disaster. With society’s consent we can further implement drones with the latest and greatest technology toward the overarching goal of creating AI drone systems. Although AI systems are still far off in the future we believe that with the right guidance of regulation and the support of anti-drone technology it may be quicker than we expect.

**CONCLUSION**

**Lumbini:**
We believe we have achieved our main objective for the project which was to study the interaction between the regulation, technology, applications and public opinion in driving the drone industry. This project has allowed us to discover an incredible number of innovative applications which we believe will fuel the future of the industry and encourage the development of better and safer technology.
Korza: Going back to the infographic, advances in technology give drones more tools to operate with. However, the utilization of these tools depends highly on regulation and public opinion.

Alex: As we have seen, regulations (primarily in the U.S.) have been sufficient, but they do introduce hindrances to the adoption of drone technologies, which limits its growth in several sectors. Furthermore, public perception of the technology has been held back by fear and lack of information.

Nick: Regulation has a particularly interesting consequence on drone growth because in order to protect the public from fear of drone misuse, regulations must be introduced. However, in order to sustain a friendly environment for commercial use of drones, regulations must be streamlined. To put it simply, there must be a balance.

Korza: To answer to the two questions posed before—(1) To what extent is the technology there? and (2) How much are the government and the public on board?—the technology is progressing steadily, but varies from application to application; getting the government and the public on board takes well-balanced regulations, which will take time to perfect.

Jamie: We believe that by bringing the applications which positively affect society into light, we will educate the public and allow them to see a drone industry outside of the military.

We would like to thank Professor Rissmiller for bringing together 5 really passionate people to work on this project. Our various backgrounds and perspectives on the subject has allowed us to form a unique perspective that represents the drone industry as a whole. Thank you for your time and attention. We will now open the floor to any questions.