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Unmanned Aerial Systems

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In January of 2013, DJI, a relatively new and unknown company from China introduced the first consumer-grade unmanned aerial system. It gave users the ability to capture stable aerial imagery with little to no experience, minimal setup time, and at an accessible price point. They called it a "small size Ready-to-Fly VTOL, integrated multi-rotor aircraft for aerial filming," and it started the UAS revolution (DJI, 2018).

Prior to this, UASs were primarily a surveillance tool for the military with a history dating back to World War I. These systems were largely based on designs and inventions patented by Nikola Tesla in the late 1890s, combined with the invention of the heavier-than-air craft made popular by the Wright brothers at Kill Devil Hills, NC in 1903. Tesla's U.S. patent application 613,809 in 1898 accurately foretold the impact that unmanned craft would have in the future (Atherton, 2016). "Vessels or vehicles of any kind may be used, as life, dispatch, or pilot boats or the like, or for carrying letters, packages, provisions, instruments, objects, or materials of any description, for establishing communication with inaccessible regions and exploring the conditions existing in the same" (United States Patent No. 613,809 , 1898).

Unmanned Aerial Vehicles (UASs), best known as Drones, are of ever-increasing popularity, and have given birth to an entirely new industry that encompasses the design, manufacturing, distribution, training, operation, and reporting.

It is in these exact roles that UASs are now creating a new and growing Unmanned Aircraft industry. Altogether new companies focus on the design/manufacturing, training, operation, and reporting on developments related to UASs, impacting agriculture, law enforcement, emergency response, communication, construction, and aerial photography among others. By 2025, some analysts expect over 100,000 new jobs and an economic impact of $82 billion directly related to UASs (Chamata, 2017).

This paper provides an analysis of each of the four major areas listed regarding UASs, as well as an analysis on how UASs are impacting four preexisting industries: construction/infrastructure maintenance, law enforcement/emergency management, agriculture, and aerial photography.

Keywords: Unmanned Aerial Vehicles, Aerial Photography, DJI, Drones, FAA, Disruptive Technology, Aviation, Law Enforcement, Emergency Response, Agriculture, Construction

Introduction

Throughout the history of Aviation, it is the unmanned aircraft, not manned aircraft, that were first to achieve historical accomplishments. The first lighter than air flights occurred in 1783 in France with no one onboard. In 1896 the first powered heavier than air flight was a steam powered unmanned craft launched by Dr. Langley from a house boat in the United States, six years before the Wright Brothers flew their historic manned flight in 1903. Unmanned aircraft achieve transonic speeds (i.e., speeds close to that of sound) today, but humans have yet to do so with anything other than the now cancelled space shuttle program, where transonic flight occurred only upon reentry as they glided back to earth.

Since writing *A Survey of Issues Related to Integrating Unmanned Aerial Systems (UAS) into the National Airspace System (NAS)* in 2008, this author has seen the use of Unmanned Aerial Systems, otherwise known as "Drones" by both commercial enterprises and the general public, grow significantly in popularity and utility (Spencer, 2008). With a history dating back to World War I, UASs were once just a military tool for surveillance, largely based on designs and inventions patented by Nikola Tesla in the late 1890s and the invention of the heavier-than-air craft made popular by the Wright brothers at Kill Devil Hills, NC in 1903. UASs now execute military strikes in foreign countries, inspect critical infrastructure, assist firefighters and search and rescue crews, and deliver products to your door.

> "We're ushering in a new age of American aviation: the unmanned aircraft era. And it's moving at a quicker pace than anything we've seen before" (Huerta, 2017).

Prior to UASs, Tesla's U.S. patent application 613,809 in 1898 accurately foretold the impact that unmanned craft would have (Atherton, 2016). "Vessels or vehicles of any kind may be used, as life, dispatch, or pilot boats or the like, or for carrying letters, packages, provisions, instruments, objects, or materials of any description, for establishing communication with inaccessible regions and exploring the conditions existing in the same" (United States Patent No. 613,809, 1898).

The Federal Aviation Administration (FAA) requires that all unmanned systems are registered, and the number of registered systems is growing at a substantial pace. In January of 2016 300,000 such systems were registered, and that grew to 670,000 by January of 2017, and surpassed 1,000,000 in January of 2018 (Kratsios, 2018). By the estimates of key leaders in the FAA, there are at least as many unregistered, non-cooperative systems and operators in the United States, bringing the total number of UASs beyond 2 million in January of 2018. For an industry that only began selling their products in mass in January of 2013, with the introduction of DJI's first consumer-grade unmanned aerial system, this has been explosive growth.

By giving users the ability to capture stable aerial imagery with little to no experience, minimal setup time, and at an accessible price point, DJI introduced what many are calling one of the most disruptive technologies of this century. Acting Director of the FAA, Michael Huerta stated in January of 2017 that, "We're ushering in a new age of American aviation: the unmanned aircraft era. And it's moving at a quicker pace than anything we've seen before" (Huerta, 2017). This disruptive technology is just beginning to find its place and continues to test its limits in an already established infrastructure designed around the evolution of manned aviation, grounded in decades of lessons learned and lives lost.

The Industry

The UAS industry is global, but the primary market for this analysis is the United States. This is necessitated by three reasons: the extreme variance in regulatory frameworks surrounding UASs in various countries introduces variables that accounting for becomes cumbersome and add little to no value, the United States is known for having the most complex airspace system in the world, and transparency and access to market information is much greater in the United States than in many other countries.

This paper looks at the UAS Industry in the United States and breaks it into four components: design/manufacturing, training, operation, and reporting on developments related to UASs. It also provides an analysis on how UASs are impacting four preexisting industries: construction/infrastructure maintenance, law enforcement/emergency management, agriculture, and aerial photography. A broad scope is selected to give the reader a greater understanding of the market and the driving forces behind it, since the industry is relatively new and general understanding of this industry is in its infantile stages.

DroneDeploy, one of the three leaders in commercial UAS mapping software, ranks the DJI "Phantom 4 Pro as the most popular mapping drone" followed by DJI's "Mavic Pro at 27 percent" and DJI's "Phantom 4 is the third most popular drone, used by 16 percent pilots" (Juang, 2018). Due to the number of these systems now being used for commercial purposes, the impact of small UASs on manned aviation, and their impact on the manned aviation industry--they are the focus of this Industry Analysis. Follow on Industry Analyses will dive deeper into each of the submarkets discussed here as they mature and as industry leaders mature.

Stakeholders

As with many industries, UASs have design/manufacturing, training, operation, and news outlets that report on industry developments. With commercial and recreational UASs being relatively new to market, based on rapidly evolving technology--it is important to consider how each of these categories of stakeholders impacts the development of the UAS industry.

The designers and manufactures of UASs play an important role in shaping the industry, but there are also commercial and hobbyist users, regulators, reporters, and the non-participative but nonetheless impacted community. Not included in the design and manufacturing of UASs for this analysis are manufacturers of cameras, imaging systems, propulsion, navigation, or other components, or anyone who designs and manufactures accessories, supporting software, and add-ons.

There are a wide variety of UAS users, from those that have simple recreational systems to others that operate sophisticated and specialized commercial UASs. Real estate photographers, home inspectors, construction companies, utilities, cell-phone providers, farmers, miners, fish and wildlife, and emergency response agencies are just a few of the operators.

In addition, Unmanned Aerial Systems operate in the same environment and space as existing manned aircraft and guidelines are already established. UASs then infringe not only on the physical space, but also upon the stakeholders of manned aviation. In particular, passenger airlines, cargo carriers, and for hire commercial carriers including corporate aviation, general aviation, the Federal Aviation Administration and their 14,050 air traffic controllers, and even model aircraft hobbyists are all significant stakeholders in the evolution of the UAS industry and must be considered here (FAA, 2017c).

Supporting all of these are the researchers, who test new unmanned technologies for fielding to solve the problems of today. Seven FAA sponsored locations across the United States, run by partnerships with academic, governmental and commercial affiliations, are exploring new technologies to deconflict the existing manned aviation from the new unmanned craft, detect errant and mal-intentioned systems, and extend the loiter time and range of future UASs.

Methodology

This Industry Analysis is the first of a three-paper series to fulfill the requirements for the DBA degree at the University of South Florida. Accompanied with the second paper summarizing expert interviews and a third synthesis paper, this Industry Analysis is the first step in exploring the Unmanned Aviation Industry and the key obstacle(s) that impede growth.

The UAS industry is rapidly changing, with technological breakthroughs and regulatory initiatives shattering underlying assumptions almost weekly. This industry analysis was undertaken to better understand the industry as it exists today. Both formal and informal interviews of industry experts were conducted, as well as searches in JSTOR, Google Scholar, and with the assistance of the University of South Florida's librarians.

As an emerging industry, there is very little academic literature that looks at the industry as a whole, and since the number one supplier of UAS systems is from China where there are no requirements to publicly release sales data, the size of the market is left to estimates and the insights of experts. Out of necessity, the primary sources of information for this industry analysis are reports from UAS news reporting organizations, speeches by industry experts at conferences, expert interviews, and the websites and public affairs releases of major players in the UAS Industry. In the course of research, it was found that very few studies of the UAS industry have been done, and those that are available, repeat the same forecasted numbers. Due to the volatility and uncertainty of this emerging industry, it is unlikely that the forecasts would be the same unless they were using the same source. This may indicate that there is a significant lack of independent research in this industry.

Analysis

According to Michael Kratsios, Deputy US Technology Officer, and Executive Assistant for the President, UASs will contribute to 100,000 new jobs and provide nearly $80 Billion in economic impact in the United States over the next decade, but: "errant use poses unique safety and technological challenges" (Kratsios, 2018). It is these two opposing potential results that pit the advocates for fully integrating UASs into the National Airspace System against those that warn for caution and separation. The profit potential of being the market leader in a new industry clashes with an already established manned system that is recovering from years of losses following September 11, 2002. In addition, regulatory agencies whose mission is the safe and efficient utilization of airspace, particularly of existing manned aviation, clash with users who want unrestricted and free access at any time and may not necessarily understand the regulatory environment of the complex airspace system they want to occupy. UAS sales are growing irrespective of this, with sales doubling annually from 2013 to 2017, reaching an estimated 2.4 million units sold in the US in 2017 (Scott, 2017) (Meola, 2017).

Regulatory Environment

Unmanned systems attempt to operate in airspace designed and regulated based on decades of experience in manned aviation, dating back to the Air Commerce Act of 1926 (FAA, 2017a). The FAA in its current form, which emphasizes "Safety First, Last, and Always," was realized in 1958 with the passing of the Federal Aviation Act (FAA, 2017a). The first unmanned system to get authorization to fly within the National Airspace System (NAS) was the Global Hawk in 2003, nearly 100 years after the Wright Brothers made their historic first flight (Wall, 2003).

Due to "growing demand for public use unmanned aircraft operations," in February of 2007 they issued UAS Policy 05-01, and defined an unmanned aircraft as: "a device that is used, or is intended to be used, for flight in the air with no onboard pilot. These devices may be as simple as a remotely controlled model aircraft used for recreational purposes or as complex as surveillance aircraft flying over hostile areas in warfare" (Sabatini, 2007). This policy was the first of many attempts to fold UASs into the regulatory structure of manned aviation and marks the true beginning of the FAA's attempts at comprehensive regulatory action regarding UASs. It was only a first step, meant to start the process that they knew would take years to complete, but in 2007 there was no way to know how, when, or how quickly UASs would explode onto the marketplace. Large winged aircraft similar in shape and size to manned aircraft were the only systems available, were only operated by highly skilled professionals, and the UASs in development at labs and research centers around the world were only dreams that were generally not seen as something marketable in the near future. The urgency to create a comprehensive integration policy was not what it is today, and it worked well in 2007 with the regulatory processes the FAA had to follow.

The process the FAA follows when regulating air traffic is dictated by Federal law to ensure that all impacted stakeholders have an opportunity to be heard, and that the executive branch can ensure that any new regulation matches their policy goals. It is comprehensive and time intensive by nature, but the required coordination and reviews are the result of lessons learned over decades of federal regulatory proceedings. An *Unmanned Aircraft System Regulation Review* published in 2009 comprehensively analyzed "the applicability of Title 14 Code of Federal Regulation (CFR) to unmanned aircraft systems (UAS) operating in the National Airspace System (NAS)" to determine what regulations apply, what did not apply, and what may apply for unmanned systems (see Figure 1) (Kirk, Marshall, Trapnell, & Frushour, 2009). Title 14, Chapter 1 of the Federal Regulations applies to the Federal Aviation Ad-

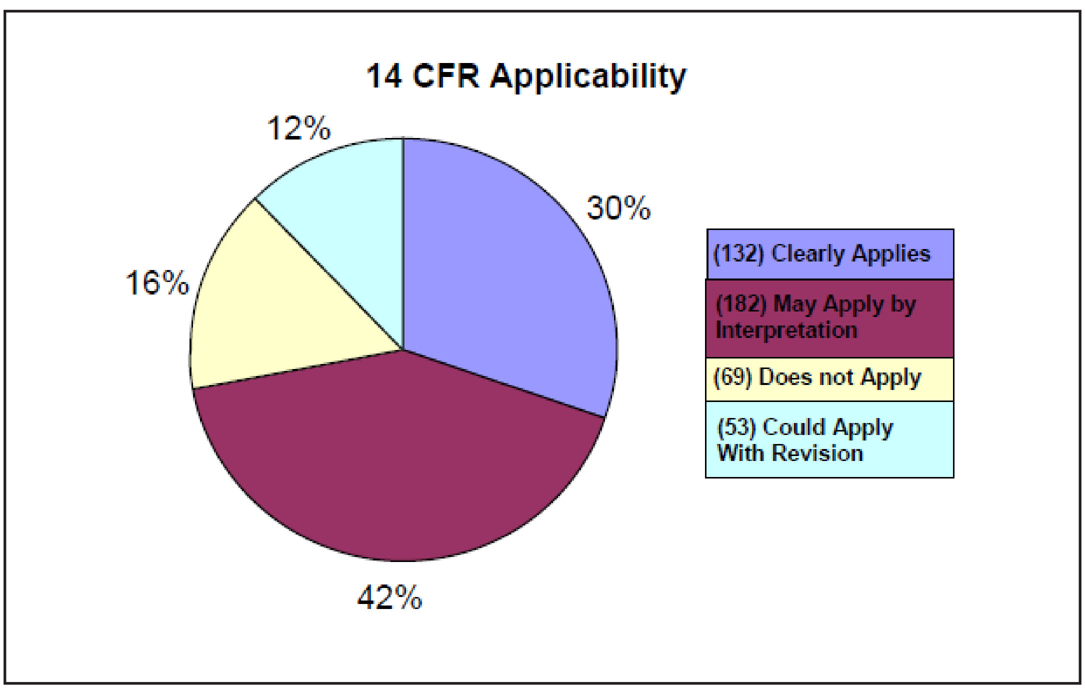

Figure 1: Title 14 Code of Federal Regulation (CFR) Applicability to Unmanned Aircraft Systems (UASs) (Image extracted from DOT/FAA/AR-09/7).

ministration, with 12 defined subchapters covering all areas of aviation from sea level to an altitude of 60,000 feet.

This report could have been the springboard to a comprehensive overhaul of regulations to prepare for UASs, but instead the FAA took a slower and more piecemeal approach. It was not until November of 2013, when they published the *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap*, did a seemingly refocused effort on UAS integration begin. Although a lack of presence of UASs may be partly to blame, the five-year long battle to get a long-term reauthorization and funding bill passed may explain more (National Business Aviation Assoc., 2012). Without a clear direction it is difficult for an organization to accomplish new and complex tasks.

It was section 333 of the FAA Modernization and Reform Act of 2012 (FMRA) that commercial UAS operators were able to use to get access to airspace, until Part 107 was released in 2016 (112th Congress (2011-2012), 2012). Section 333 was a complex code designed to ensure safety while allowing professional UAS operators access to the airspace. The FAA's goal was to respond to requests within 120 days, but it usually took much longer for the petition under section 333 to be approved. In the four years ending in September of 2016, only 5,551 petitions were granted across the entire United States (FAA, 2018a).

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Part 107 streamlined the requirements and made the requirements for access to the airspace easier to define, but still forbid commercial operations within 5 miles of metropolitan airports and below 400 feet above ground level. The waiver process for these restrictions is still complex, and as of March 2018, over 12,000 waiver requests were awaiting review at the FAA's UAS Integration Office (FAA UAS Symposium, 2018). To make it even more complex, operators with Part 333 approved petitions can still operate under those rules, or under other parts of Title 14 as well.

A UAS can operate as an Experimental Aircraft, can fly if granted a Type Certificate, operate as a Public Aircraft, or even follow Part 101 guidance for hobbyists. In each of these cases the rules become even more complex and are typically attempted only by large UAS systems operators. Ultimately, very few commercial UASs attempt to use rules other than Part 107. No one other than emergency responders and law enforcement officials fall under Public Aircraft guidelines, and Part 101 is designed for model aircraft operators. The process to get a Type Certificate is extremely complex and time consuming, and to qualify as an experimental aircraft is almost as labor intense. Only the most specialized and experienced organizations attempt these endeavors. It is for this reason that this Industry Analysis focuses on Part 107 operations.

An item of note is that the entire UAS Integration Office consists of just 13 employees. With an office this small, it would be impossible to enforce Federal UAS Regulations across the country, nevertheless process waivers for those that are attempting to operate in the defined limits. As a result, many small UAS operators operate without following these regulations, and it is impossible at this time to know how many do this or measure the impact to a reasonable level of accuracy on businesses operating legally.

Beyond anything, FAA regulations are designed to keep the passengers of commercial airlines safe. The regulations of aviation are built upon the mistakes and failures of those that came before, but all aviation regulations have the caveat that the pilot is the ultimate authority for the safe operation of his or her aircraft. As one example, Part 121 of FAA regulations state that: "In an emergency situation that requires immediate decision and action the pilot in command may take any action that he considers necessary under the circumstances. In such a case he may deviate from prescribed operations procedures and methods, weather minimums, and this chapter, to the extent required in the interests of safety" (Federal Aviation Administration, 2018). It is with this culture of safety and pilot authority, developed over 100 years of flight that commercial aviation within the United States operates.

Design/Manufacturing

The design and manufacturing of UASs for civilian commercial purposes may have many starting points, not the least of which being 2010 when a French company called Parrot introduced their AR.Drone at the commercial Electronics Expo (Johnson, 2010). The true explosion of UASs onto the market began when DJI introduced their Phantom quadcopter in January of 2013, which was the first consumer-grade unmanned aerial system that could be easily paired with a high-resolution camera. Although other systems can claim their roots to earlier dates, including the Predator from 1994 or the Boeing Insitu ScanEagle from 2002, DJIs Phantom made a highly complex and formerly expensive technology accessible to the general public. As of 2017, "More than two-thirds (68%) of all drones weighing over 250 grams are purchased for professional purposes," and DJI systems hold a "72% global market share for drone purchases across all price points," making DJI systems the largest commercial UAS platform (Snow, 2017b). This is by definition, a disruptive innovation.

Unmanned Systems Technology, a "dedicated directory of component, service and platform suppliers within the unmanned systems industry," categorizes UAS manufactures into five categories today. In these categories, there are six Aerial Target Manufacturers, 33 Fixed Wing UAV Manufacturers, four Hybrid VTOL UAV Manufacturers, six Unmanned LTA, Blimp & Aerostat Manufacturers, and 48 VTOL UAV & Multirotor Manufacturers (Unmanned Systems Technology, 2018). The most popular and well know DJI, Parrot, and 3DR systems all fall within the crowded VTOL category, but between them they owned a commanding market share in 2016, speculated by some experts as over 90 percent.

This dominance is a direct result of their popularity in December of 2013, when many fledgling UAS pilots with no flying background found themselves with a nearly ready-to-fly UAS under their Christmas tree. DJI, Parrot, and 3D Robotics (3DR), make up most of the UASs used not just for hobbyists, but for commercial purposes as well. Yuneec, Zero Robotics, Intel, and Hubsan are also players in the market, but their power in the marketplace is limited to the role of follower in most commercial applications rather than innovator or leader. The leaderboard is changing in 2018, with market leader, DJI, shoring up their position with price cuts and new technologies that make it difficult for their competition to sustain business. Some of the more notable competitors are included in greater detail below.

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DJI

DJI had "90 employees and $4.2 million in revenue in 2011" and "grew to 1,240 employees and $130 Million in revenue in 2013," the year they introduced their Phantom UAS (Nicas & Murphy, 2014). With a price of around $700 per system when initially released, this equates to nearly 186,000 UASs sold in 2013. Estimates from the FAA now place operable UASs in the United States to be just over 2 million, and DJI is known to control approximately 70 percent of all UAS market share. With these assumptions, DJI is by far the number one manufacturer of aircraft in the United States, beating out all rivals to include Boeing, Airbus, and Cessna combined. Cessna, one of the most popular aircraft manufactures ever prior to this, has produced only 43,000 Cessna 172s since 1956 (Dowling, 2017).

Since introducing the Phantom, updated versions with significant upgrades in navigation, stability, obstacle avoidance, and user functionality, as well as entirely new systems designed for smaller personal use and more advanced commercial users have rolled off the production lines. Lower end systems include the Phantom 1 thru 4 series, the Mavic and Spark for more personal use, and the Inspire 1 and 2 with the ability to mount professional grade cameras and video equipment for commercial, news, and mid-level movie productions. Industrial systems now include the Spreading Wings 1000 meant for ultra-high resolution DSLR cameras, and the Matrice 600 Pro that runs on six batteries, has a payload capacity of 6 Kilograms, and can fly for nearly 40 minutes (DJI, 2018). These larger systems cost upwards of $10,000. Based on comments during an interview in June of 2018 with the head of Corporate Communications, several more industrial grade systems are to be introduced shortly, showing an increasing focus on commercial systems rather than recreational ones.

Parrot

Parrot introduced the first UAS available at a price point targeted for the general public in 2010, and in 2013 their sales matched DJI in volume. Since then, they have taken a far second place in the UAS market. In January of 2017, they announced that: "290 staff members will be laid off out of the company's 840 employees" as a result of fierce competition from DJI (Grigonis, 2017). Although sales were "63 million dollars, with 11.6 million attributable to commercial drones," the decision was made to focus on commercial UAS systems where margins are expected to be higher (Grigonis, 2017). Data related to this effort to switch their strategic focus is unavailable at this time, but the move is similar to the strategic shift that DJI is also making.

3DR

In 2013 while DJI and Parrot were reporting sales approaching 200,000 units, 3DR touted sales figures in the "tens of thousands" (Hoge, 2013). Although seemingly successful at first, led by a founder of *Wired* magazine, 3DR abandoned the production of UASs and focused only on software. This was one of the most high profile UAS manufacturers squeezed out of the market by lower priced DJI systems. As of June 2018, 3DR has made their mapping software available for use with DJI platforms.

Intel

Intel has made themselves a player in the commercial UAS market by carving out a niche with swarm technology for entertainment. They were scheduled to perform at the opening ceremonies of the 2018 Winter Olympics, but failed to get airborne. Television viewers were none the wiser as the performance was pre-recorded and on screen--it appeared to be playing out in real-time. Intel is also responsible for a *Time* magazine cover--958 UASs flew at dusk to outline in the sky what looked like the cover of the magazine (Fitzpatrick, 2018). Disney also partners with Intel for special occasion light shows of a similar nature (Kaplan, 2016). Although Intel does have a smaller commercial UAS branch that designs and builds UASs for true commercial use, they are still a small market player. By using the partnerships with established, well-known organizations and events, Intel is likely announcing their intention to increase competition in the commercial UAS sector and may become a major player soon.

Others Including Large UASs

Others like Intel, Boeing, Northrop Grumman, and AeroVironment have successful commercial UASs that are much larger and serve highly specialized purposes. Ranging in size from a few ounces to 32,000 pounds, with the ability to fly at all altitudes occupied by commercial manned aircraft--these systems are primarily used by governmental agencies and the military. Although unmanned, they do not resemble in any way the copter derived designs used by DJI and look more akin to traditional winged aircraft.

> As of July 2018, 21 accredited colleges and universities are known to offer programs in UASs, not all of which lead to a UAS specific degree.

The ScanEagle now owned by Boeing, a company long known for commercial passenger and cargo aircraft, is likely the most successful large UAS ever built. It was originally designed to track schools of Tuna in 2005, but the platform's capabilities were found to be good for a variety of specialized commercial applications. Although larger systems like this are important and test technologies that will eventually transition to civilian applications, these are not the UASs that are shaking up manned aviation today. Many of these systems existed in the late 90s and early 2000s, but it was not until 2013 that the commercial UAS revolution began, specifically with DJI and Parrot.

Training

In just one year after the introduction of Part 107, the commercial UAS pilot certification standard, which became effective on August 29, 2016--just over 100,000 people earned their Part 107 rating (FAA, 2018c). These pilots received their training from one of five types of aviation training organizations, of which three were not in existence prior to 2009. While some traditional pilots have added the UAS rating to their certifications list and were educated at one of the manned aviation training schools, technical schools, or through the military--new UAS training organizations have emerged in three types of organizations to provide inexperienced students with the knowledge needed to pass the FAA's Part 107 exam. Universities and Colleges provide a variety of degree earning programs, while other businesses and professional interest groups provide short-term hands-on technical education, or students take online/distance/CBT based training.

Universities/Colleges

As of July 2018, 21 accredited colleges and universities are known to offer programs in UASs, not all of which lead to a UAS specific degree. Nine others are core members of the FAA's Alliance for System Safety of UAS through Research Excellence (ASSURE) Center of Excellence on Integrating UAS in the National Airspace System and conduct significant research related to UASs, but do not have specific degrees or minors for UASs. Traditional manned aviation powerhouses like Embry Riddle Aeronautical University (ERAU), the University of North Dakota (UND), and Kansas State Polytechnic, were among the first to offer degrees in UASs by expanding their manned aviation schools. New Mexico State University runs the first FAA testing center for UASs, and the University of Alaska, Fairbanks, recently became one of 10 selected for the FAA's Unmanned Aircraft Systems Integration Pilot Program that began in 2018.

These pipelines are responsible for less than one percent of current certified commercial UAS operators, with only 476 students enrolled as of the Fall 2018 semester in the two largest four-year programs at UND and ERAU combined. This does though provide an additional revenue stream for these universities with students who may be interested in aviation careers, but are not qualified or interested in manned aviation. In addition, the research generated benefits the industry as a whole by advancing technology, testing procedures, and building awareness through partnerships with civil and military organizations that would not be practical for commercial UAS operators to pursue.

Table 1 lists the identified institutions, notes the degrees available, and provides a few significant accomplishments or affiliations each school has. Trade or technical colleges without traditional academic requirements are not included in this list.

This list is relatively short, but it is in some ways

Table 1: Accredited college & university programs in Unmanned Aircraft Systems (UAS) Operations

Academic Institution Name	Degree Offered	Notes
University of North Dakota (UND)	B.S. in Aeronautics with a Major in Unmanned Aircraft System Operations	Selected as one of six FAA testing sites in December 2013 (Pedraza, 2013) On North Plains UAS Authority Executive Board with North Dakota State University (NDSU) which focuses on the engineering and design aspects but does not have a UAS specific degree track According to E. Bjerke, Associate Dean, 194 students in UAS programs, 1,425 students enrolled in traditional programs (personal communication, July 23, 2018)
Embry Riddle Aeronautical University (ERAU)	B.S. in Unmanned Aircraft Systems Science, Master of Science in Unmanned Systems, Undergraduate Minor in Unmanned Aerial Systems	Operates campuses in Prescott AZ, Daytona Beach FL, online, and through dual-enrollment programs with High Schools in Florida 282 students in UAS degrees, 2,951 in traditional programs (Embry Riddle Aeronautical University, 2018)
University of Alaska, Fairbanks	N/A – embedded within Aerospace Engineering or Aviation Maintenance Undergraduate Programs	Selected as one of 10 organizations for the U.S. Department of Transportation's Unmanned Aircraft Systems Integration Pilot Program
Purdue University, Polytechnic Institute	B.S. in Unmanned Aerial Systems	
Central Oregon Community College	AAS Degree in Unmanned Aerial Systems	
Oklahoma State University	Option in MS and PhD in Mechanical and Aerospace Engineering	OSU's Multispectral Lab is a test bed for advanced military technologies, including unmanned systems
Texas A&M University, Corpus Christi	Embedded within Department of Engineering with no academic options specific to UAS	On the forefront of UAS research as one of six locations selected by the FAA for UAS testing, but growth from testing center to an academic focus on UASs has not occurred
Troy University, Alabama	Minor in UASs coupled with the Bachelor of Applied Science in Resource Management and Technology under dept. of Chemistry and Physics, A.S. in Unmanned Aerial Systems	
Indiana State University	B.S. in Unmanned Systems, Minor in Unmanned Systems	Industry partnerships include Beck's Seeds (6th largest seed producer in United States), and houses the "Center for Unmanned Systems and Human Capital Development" to collaborate with the departments of Criminology, Electronics and Computer Technology, and Earth and Environmental Sciences

Lewis University, Illinois	**B.S. in Unmanned Aircraft Systems**	**Operations focused, with active partnerships at both O'Hare and Midway International airports for manned aviation program**
Middle Tennessee State University	**B.S. in Aerospace with a concentration in Unmanned Aircraft Systems Operations**	
University of Nevada, Reno	**Minor in Unmanned Autonomous Systems for any Undergraduate Engineering Degree**	**Not aerial specific**
Kent State University, Ohio	**B.S. in Aeronautics with minor in UAS**	**Awarded a research and development agreement (CRADA) worth $130,000 for scalability of quadcopter designs to larger systems**
University of Louisiana at Monroe	**B.S in Aviation with concentration in Unmanned Aircraft Systems, Post-baccalaureate Certificate in UAS**	**Mainly focused on Agricultural applications, but training is similar to other fields**
Community College of Beaver County, Pennsylvania	**A.A.S. in Unmanned Aerial Vehicles**	
California Baptist University	**B.S. in Aviation Unmanned Systems**	
LeTourneau University, Texas	**B.S. in Remotely Piloted Aircraft Systems**	
Green River Community College, Washington	**A.A.S. in Unmanned Aerial Systems, UAS Basic Operator Certificate**	
Liberty University, Pennsylvania	**B.S. in Aeronautics: Unmanned Aerial Systems**	**Two tracks available – operator and mechanic**
Sinclair Community College, Ohio	**A.A.S. in Unmanned Aerial Systems**	
Northwestern Michigan College	**B.S. in Engineering Tech with minor in UAS Operations**	**Started in Fall of 2010, now offers 4 courses in UASs**
Mississippi State University, Drexel University, Montana State University, New Mexico State University, North Carolina State University, Oregon State University, University of Alabama-Huntsville, The Ohio State University, Wichita State University		**Core members of the FAA's Alliance for System Safety of UAS through Research Excellence (ASSURE) Center of Excellence on Integrating UAS in the National Airspace System. Significant UAS research but no specific academic degrees or programs focused on UASs.**

very similar to manned aviation educational institutions. For example, there are the 216 schools out of the 4,627 degree granting institutions in the United States that offer Aviation training, but there are only 37 Universities and Colleges who offer aviation training that is rigorous enough to meet the Restricted Air Transport Certification (R-ATP) requirements of the FAA for pilots (Aircraft Owners and Pilots Association, 2017) (Chepkemoi, 2017) (United States Government Accountability Office, 2014). These schools train professional pilots to a higher standard that qualifies them for commercial flight with fewer hours in the cockpit than their non-certified counterparts. An Air Transport Certification (ATP), which is required to fly commercially with passengers onboard, is typically only available after 1,500 hours of flight experience. An R-ATP certified program can get you flying commercially with either 1,250 or 1,000 hours depending on the level the training location is certified by the FAA. The "R" is dropped after you reach 1,500 hours of experience. There is no equivalent certification yet for UAS operators.

In addition to these 216 manned aviation schools, there are also hundreds of technical school locations that specialize purely in-flight training for manned aviation with no coursework beyond the minimums that are prescribed by the FAA for pilot certification. In Florida alone, there are 169 such locations, but listing them or going into significant detail is beyond the scope of this paper (Aircraft Owners and Pilots Association, 2018). These location's primary goal is to get a student to 1,500 flight hours to obtain their Airline Transport Pilot (ATP) certification, and some do so in as little as two years. UAS training is similar as well in this area, with the counterpart to these manned aviation technical programs in shorter term technical programs.

> **There are several short-term technical training options available to someone pursuing a commercial UAS operator's certification or additional UAS specialty training.**

Short-Term Technical

There are several short-term technical training options available to someone pursuing a commercial UAS operator's certification (Part 107) or additional UAS specialty training. A simple search online yields a multitude of options ranging from intensive one-day test preparation courses, 2 and 3-day training programs, computer-based training, and mixtures of all three. The longer the course and the proximity of affiliation to a traditional university or college sometimes shows how extensive the training is, but this is not always the case. Some of these programs are offshoots of pre-existing manned aviation training schools, while others are entirely new enterprises. Table 2 lists just a few of the more notable programs and provides some notes about each, but enrollment numbers are not readily accessible for all.

In addition, some larger university and college programs offer short certification programs to get you ready for the Part 107 exam or provide additional training. ERAU's Professional Program in Small Unmanned Aircraft Systems (sUASs) is one such example. Topics such as navigation and flight planning, the makeup of the National Airspace System, flight performance, payload planning and handling characteristics, weather, and crew resource management for sUAS are covered. FlightSafety, a provider of pilot training for airlines and the military, also offers a series of elective courses that include line-of-sight and beyond visual-line-of-sight (BVLOS) flight training, commercial sUAS operations management, risk-analysis programs in sUAS, and a UAS inspection class. These classes are not geared toward obtaining a Part 107 certification, but appear to target advanced users who desire additional knowledge in these areas.

There are also one-time training sessions held by professional organizations who provide training both in Part 107 certification as well as continuing and developing education at conferences and industry exhibitions. AUVSI, the Association for Unmanned Vehicle Systems International, is the largest of these organizations and partners with the FAA several times a year. The annual UAS Symposium is one of the largest UAS events in the country, only overshadowed by Interdrone's annual commercial UAS expo. Typically, the day prior to the main event, these organizations hold a one-day training that is designed to prepare an individual for the Part 107 exam.

It is important to note again that none of the programs or organizations providing these programs had this type of training available, or in many cases this type of training did not even exist prior to 2009.

Online/Distance/CBT Based Training/Books

Unlike the previous sections, these types of training organizations are simply in the business of passing on just enough information to pass the Part 107 test, at the lowest cost to the customer. Many online programs have pre-recorded lessons, some include access to instructors to answer questions, and other are simply a CD or book that you study at your own pace. Many programs promise that you will pass the exam, or you get your money back, and typically cost anywhere between $14 and $200. There are far too many to list here individually, but considering that over 100,000 individuals now have commercial UAS

Table 2: Short-term technical training options for Unmanned Aircraft System (UAS) Operations

Name	Website	Notes
UAV Coach	https://uavcoach.com/	Founded in 2014, over 10,000 trained commercial UAS pilots. Offers a variety of courses including Part 107 certification. A 90-minute training session with 35 minutes of hands-on flying with an instructor costs $199.
Unmanned Vehicle University	http://www.uxvuniversity.com/uav-pilot-training-certificate/	3-phase training for $3,500, with ground school, UAS simulator, and hands-on training at 9 locations nationwide. Just over 2,000 trained, and expanding to 150 schools across 11 states (Creedy, 2018).
Dart Drones	https://www.dartdrones.com	Featured on Shark Tank, provides in-person, online, and industry workshops for individuals and 11 different professional applications, as well as test prep. Prices from $20 to $1,650. 8,604 trained as of July 11, 2018 (A. Owre interview, 2018, July 12).
Unmanned Safety Institute	https://www.unmannedsafetyinstitute.org/	With over 5,500 trained students, and over 160 certified instructors, they are the standard for Industry Certification and partner with schools like ERAU.
Vale Training Solutions	https://www.valetrainingsolutions.com/	Provides training for everything from car mechanics to UASs. Example of a company with a very small section of business dedicated to UAS test prep. Hundreds of companies like this.
MAG Aero	https://magaero.com/	Example of an aerospace training and service company with a specialty in mid-sized to larger UASs. Tailored to for hire commercial and military applications, they added unmanned operations in 2013. Trainers have over 30,000 logged hours of UAS experience and the company is a partner of the Alliance for System Safety of UAS through Research Excellence (ASSURE)

licenses, the top aviation universities graduate less than 1,000 unmanned specialists per year, and just under 26,000 trained with short-term technical--it is probable that the other 33,000 and counting received their training via these methods.

Operation

Although the manufacturers can bring the technology to market, it is the user who finds innovative uses for it and brings commercial viability to the product. The UAS operators are some of the most visible industry members and have adapted this technology meant for recreational use and turned it into a revolutionary commercial asset in existing industries. Although real estate and professional photography were fairly obvious transition points, UASs now play a role in many more arenas that are not as evident. In most cases, the use of UASs is limited to optical and other sensory collection. In the future, UASs are expected to provide delivery services for the "last mile" of the logistics chain, as well as provide passenger transportation services. The industries discussed below are currently using UASs and are assumed to operate in complete compliance with Federal Regulations. It is known that many small UAS operators ignore these requirements and have yet to see consequences.

Aerial Photography

The first balloon flight occurred in 1783 at Versailles, and Joseph Nicéphore Niépce invented photography in Paris around 1826, so it was only a matter of time that the two technologies would be used in unison (Research centre of the Palace of Versailles, n.d.) (Harry Ransom Center, n.d.). Aviation was long used for surveillance and intelligence as the ultimate high ground, so being able to capture imagery for detailed analysis beyond what a single person could remember on their own or deem important was priceless. In 1858, the first known aerial photograph was taken, again in France, when both aerial platforms and cameras had evolved enough to be used for such a purpose (Professional Aerial Photographers Association, n.d.).

Aerial photography focuses on imagery in the visible spectrum of light, and the best aerial photography companies process the raw images and turn the images into either meaningful data for customers, or high-quality images for historical or decorative purposes. It is unknown as to how many manned aerial photography companies exist in the United States, but several companies in Florida travel from Texas to New York and parts between providing imagery for customers. This indicates that there are only a few select companies that are able to provide the quality of services required for most repeat customers. The same types of images can be captured using UASs as with manned platforms, but there are limitations.

Aerial photographers across the United States today use helicopters and small aircraft with professional still and video equipment to capture significantly detailed imagery. Manned aircraft are expensive, and include the cost of aircraft rental, pilot, and fuel. Fixed wing aircraft are cheaper than rotary wing craft, but even at $120 per hour plus a pilot and fuel, the direct cost of a single shoot can run in the hundreds of dollars. A basic 3 seat helicopter can cost $600 per hour alone. There are advantages though as compared to UASs.

A UAS averaged 27 minutes of flight time, while manned aircraft can stay aloft for upwards of six hours. Manned aircraft can fly hundreds of miles and survey distant locations, or even visit multiple sites in one trip, while a UAS must stay within five miles of the transmitter and has to be transported from site to site if the distance is greater than that. Given current FAA regulations that require an operator to remain within visual sight of their aircraft, very few UASs can travel beyond half a mile before violating this rule.

Given current FAA regulations that require an operator to remain within visual sight of their aircraft, very few UASs can travel beyond half a mile.

Real estate photography is one of the areas where aerial photography has taken hold, but unless a real estate agent is a certified commercial UAS pilot, they cannot they take photographs legally at a price point worth doing for most properties. Just because an agent lists a property, does not mean they will be the one selling it. Only with luxury priced properties, or commercial real estate does the cost of aerial photography make good business sense if you have to hire an outside professional.

Talking with the owner of one aerial photography company in Florida, the owner stated that having a UAS can serve a purpose, but in most cases they are unable for either technical or regulatory reasons to meet the needs of clients. In some ways, a UAS is more of a marketing tool, since customers come in specifically asking for "drone footage," and being able to provide that helps to retain customers. It is impossible though to compete on price for a single job when a sole UAS operator with no overhead offers aerial imagery for $100. To date, this author has yet to see an operator at that price point remain a going concern for more than a few months.

Construction/Infrastructure Maintenance

Construction in the United States contributes to at least $660 billion in economic impact in the United States in the fourth quarter of 2017 alone (Federal

Reserve Bank, 2018). The top 10 private construction projects for buildings slated for 2018 are valued at $26.2 billion, and the top 10 governmental projects for buildings are over $12 billion (ConstructConnect Project Research, 2017). Highway construction expenditures in 2017 were "over 87.7 billion U.S. dollars" (Statista, 2018). Managing these large, expensive projects involving thousands of workers, making sure that not just the quality but the size and location of the work is up to standards is vitally important. Additionally, the equipment, supplies, and employees must be kept secure and safe from burglary or mishaps, but managers cannot be everywhere at all times. This is why "construction drone usage has skyrocketed by 239 percent year over year," with a large portion of this increase attributable to midrange DJI systems (Juang, 2018).

Infrastructure maintenance faces similar challenges, but includes the additional challenges faced when needing to inspect one of the tens of thousands of cellular towers, millions of miles of utility lines, or the remote and extremely difficult to get to oil and gas lines stretched across the country.

Aerial photography has long been the method of choice for its ability to provide high quality images to managers, but the cost of this imagery makes frequent checks cost-prohibitive, and managers must identify critical phases of a project that will garner the greatest value at the right time. Depending on the size of the project, particularly with highway or utility projects, manned aviation was the only way to capture the imagery due to the distance needed to travel. UASs when properly calibrated and equipped are now poised to change this.

> In 2016 "at least 167 agencies" purchased UASs, bringing the total to "at least 347 local law enforcement, fire and emergency responder agencies"

UASs have the same imagery capabilities as manned aircraft, but face the same limitations mentioned in the aerial photography section above. One advantage is that sending a UAS to survey a site can limit the number of employees in dangerous locations, or managers can routinely send a UAS to capture the latest progress on a critical task or location. A PBS report in 2012 found that "nearly 100 tower climbers have been killed on the job" with half of them occurring on cell towers (Day, 2012). Rotary wing UASs can easily scale towers and capture multispectral imagery, and fixed wing UASs can travel long distances, with some systems now able to stay airborne for as long as 10 hours. These systems are again, highly specialized and limited to larger companies with larger pockets, but the technology exists and is starting to be used. Xcel Energy on April 18, 2018, received the first BVLOS waiver under Part 107, and stated that these "flights will enhance grid reliability and safety for our employees" (Lillian, 2018). Although previously smaller UASs operators were unable to match the specific requirements of larger companies--at this time with the typical UAS, it is possible today. As equipment costs decrease, the number of commercial operators offering services to these companies will significantly increase.

Law Enforcement/Emergency Management

Any aircraft operating for law enforcement or rescue purposes is considered a "Pubic Aircraft" and has specialized regulations regarding training and use. Public entities are allowed to create their own training programs and certify their operators without taking the standard 35 question Part 107 exam administered by the FAA, and airspace waivers are not required when the operation of a UAS is specifically for law enforcement or rescue purposes. There are many unsettled legal issues regarding privacy and probable cause, but these issues are beyond the limits of this paper.

Even without these issues settled, public agencies are buying and using UASs. In 2016 "at least 167 agencies" purchased UASs, bringing the total to "at least 347 local law enforcement, fire and emergency responder agencies" with UASs (Glaser, 2017). Of the UASs purchased, almost 80 percent were manufactured by DJI (Glaser, 2017). UASs can aid the Police, Fire and rescue teams in determining the safety of an environment before entering, ascertaining the location of suspects, maintaining situational awareness during events or even searching for missing persons. Fire fighters can use infrared cameras to identify hotspots and monitor the locations and conditions of their teams or to find those that need assistance. The ability to attach both infrared and high definition cameras to highly portable and maneuverable systems provides police a perspective that helicopters and fixed wing aircraft were not able to provide before.

Police and search and rescue agencies are just learning how to use UASs and will find many more ways to employ the technology, but real-world examples of UAS use already exist. On May 31, 2018, "four people were rescued by drones in three separate incidents on two continents on a single day," with "the total number of people rescued from peril by drones around the world to at least 133" (Lisberg, 2018). The limitation is again a battery life ranging from 25 to 35 minutes, but this is sufficient for most purposes.

Agriculture

This author's first introduction to commercial UASs was in the field of agriculture in 2006. Larger systems were used like the newer mid-sized systems of today to take imagery of crops in the near-infrared and infrared to spot diseases, pests, determine nutrient requirements, and analyze irrigation needs. Some in the industry envisioned a day when UASs would carry and distribute herbicides, pesticides, and fertilizers with the aid of GPS to limit applications to the absolute minimums needed to reduce cost and minimize environmental impacts of their use.

Today, all of this is possible, but with smaller platforms. These UASs are highly specialized, can cost upwards of $10,000, and represent only a small portion of UAS sales nationwide, but UAS use has still climbed "172 percent in agriculture" in 2017 (Juang, 2018). Some models "can fly a square mile in 30 minutes," and now can track herds, help find lost animals, providing a utility again only previously possible with manned aircraft (Morgan, 2014). About 63% of agricultural users operate the systems themselves, which is easier in agricultural environments (McNabb, 2017). A typical farm is outside the 5 mile ring surrounding towered airports, placing them in airspace that allows them to fly their UASs up to 400 feet without restriction or special certification. Although the airspace outside of 5 miles from an airport is not as crowded, there are still risks. Near Charleston in February of 2018, a helicopter claimed it was almost struck by a DJI UAS (Henderson, 2018).

> The creative uses of UASs are not always in the best interest of society and may not be of the highest moral callings...

Other Applications

There are a number of other applications that UASs have, including fish and wildlife management, mining, and product delivery; the options are nearly endless and limited only by what people dream of. Amazon.com, Dominoes, UPS, DHL, and 7-11 all have had plans at one point to deliver goods "the last mile" of the logistical chain, but have not provided sufficient safety evidence to convince the FAA to allow their services to ramp up to full capacity.

The creative uses of UASs are not always in the best interest of society and may not be of the highest moral calling, but as with every new technology, there is always some negative to go with the positive. It is these people who can significantly and negatively impact industry growth.

News Outlets

There are a number of traditional aviation news outlets that report on UAS developments, with reporters now specializing in reporting on unmanned aviation. Also, many entirely new organizations report on industry developments, with the major organizations being Unmanned Systems Technology, AUVSI, UAS Magazine, Unmanned Aerial Online, sUAS News, DroneLife, and UAS Vision.

One of the largest of these new organizations, sUAS News founded in 2008, employs 9 people and continually updates readers on the latest developments in anything related to UASs, civil or military. They provide links to employment for unmanned operators, airspace maps, and categorize stories based on topics like many news agencies do. DroneLife, a mainly online service, was ranked number one by Alexa.com in 2015, and has "partnerships with over 250 commercial drone enterprises worldwide" (McNabb, 2016). AUVSI is an organization that is now 40 years old, and has an extensive database on all things unmanned, including air, land, and underwater craft.

These agencies not only employ individuals with an interest in unmanned systems, but they provide operators, manufacturers, distributers, educators, and researchers with daily updates on industry developments. Without these specialized UAS reporting organizations, this IA would not have been possible, for traditional news organizations would not provide the same detailed information at the same frequency or understanding of the industry environment.

Pre-Existing Aviation

Civil Aviation

According to the latest report from the FAA, "civil aviation accounted for 5.1 percent of U.S. gross domestic product (GDP), and generated $1.6 trillion and supported 10.6 million jobs with $446.8 billion in earnings" (FAA, 2017d). This includes all commercial carriers, both passenger and cargo, and is the preferred method of travel for most when traveling long distances or overseas. 965 million passengers and 39.9 billion pounds of cargo moved via civil carriers in 2017 (National Air Traffic Controllers Association, 2018). This was all accomplished in 2017 during the safest year ever for commercial aviation, with no fatalities due to accidents (Shepardson, 2018).

These results are not exceedingly surprising, considering the strong culture of safety within civil aviation. FAA regulations are designed to keep the passengers of commercial airlines safe. The regulations are built upon the mistakes and failures of those that came before, and the training of professional aviators reinforces this culture from day one until retirement. What does make this surprising is that operating within the same airspace as these aircraft, were 2,125 reported sightings of unauthorized UAS activity at altitudes above 400 feet or within the confines of the airspace surrounding the approach and departure of airports across the United States, which is forbidden by federal law (FAA, 2018b). Many of these reports were at altitudes in excess of 3,000 feet, with some as high as 8,000 feet. Considering the size of these systems, that all sightings are visual only as UASs currently do not have detect and avoid systems, and that commercial airlines fly between 150 and 250 knots at these altitudes, it is highly likely that thousands of other unauthorized UAS flights occurred and went unnoticed. New technologies being researched that detect the signals used to control UASs and their locations will soon shed light on the real severity of the problem.

The primary concern of civil carriers is that they do not want one of these unauthorized operations to be the mistake or failure that writes another regulation. Pilots and Air Traffic Controllers go through years of training before starting their careers and have prescribed continuing training to stay current with regulations and familiar with emergency procedures. An untrained and unknowing UAS operator in controlled airspace has the potential to cause a serious if not fatal accident. In speaking with Vice President Operations at Dallas Fort Worth International Airport and aviation safety expert Mr. Paul Sichko in June of 2018, although aircraft know the dangers of striking wildlife inflight, it is unknown what damage a composite structure powered by lithium batteries could do to a commercial airliner, particularly when it hits critical flight surfaces or is ingested into an engine (Sichko interview, 2018, June 26).

The primary concern of civil carriers is that they do not want one of these unauthorized operations to be the mistake or failure that writes another regulation.

A secondary concern is that many of the airports in the United States are already extremely busy, with Atlanta International having 2,700 arrivals and departures daily (Hartsfield-Jackson Atlanta International Airport, 2018). One errant UAS can shut down operations at a single location, but the impact would ripple through the entire aviation system with delays, missed connections, and excess operating expenses. Midsized jet aircraft cost between $6,500 and $7,900 per hour on average to operate, so an additional 10 minutes of flight time for 56 aircraft during one short incursion (average arrival rate for Atlanta over 30 minutes), can cost the industry over $65,000 (Marsh, 2015).

General Aviation

General Aviation (GA) includes the aircraft, operators, mechanics, and support personnel and infrastructure that enables anyone not involved in passenger, cargo, or military aviation to operate. The latest report on GA from PricewaterhouseCoopers defines it as the manufacture and operation of any type of aircraft that has been issued an airworthiness certificate by the FAA, other than aircraft used for scheduled commercial air service or operated by the military," and says that "general aviation, in total, supported 1.1 million jobs and $219 billion in output" in 2013 ("Contribution of General Aviation," 2015).

The GA community is very influential in the United States, and their influence is the main reason that the airspace is considered the most complex in the world. The various classes of airspace and the rules surrounding them are the result of decades of lobbying and compromises between civil and general aviation.

The pilots flying in GA are typically but not always less experienced, less current, operate less advanced and much smaller aircraft, fly at altitudes below 10,000 feet for most if not all of the flight, and often are outside of controlled airspace. GA aircraft flew over 24 million hours each year, with 164,200 fixed wing and 10,500 rotorcraft, as compared to 6,871 commercial aircraft, in operations nationwide (FAA, 2017c). All of these characteristics except for their lower operating speeds make GA much more vulnerable to UAS incursions.

The concern is again safety. With over 2 million UASs in the United States, all potentially operating in the same airspace as GA aircraft, it may unfortunately only be a matter of time before a fatal accident occurs. A strike on a control surface of a small GA aircraft, or even into the single engine that most of these aircraft use for thrust, could be catastrophic.

Model Aircraft

One of the more surprisingly influential stakeholders in the UAS industry is the model aircraft operator. Backed by the Academy of Model Aeronautics, they were influential in drafting some of the initial regulations for UASs in the 2013 to 2014 timeframe as UASs rose in popularity. Part 101 carved out model aircraft operators as separate entities that did not require the same regulatory oversight as other UAS operators, and to this day, that standard continues. This group of avid model aircraft enthusiasts started in 1936 and has a national headquarters and museum that employs at least 61 people (Academy of Model Aeronautics, n.d.). Although total membership is unknown, 58,771 people are listed as followers on Facebook.

The impact on model aircraft owners is difficult to determine. Model aircraft operators had designated airfields and airspace they stayed within long before

UASs were invented, and this author is unaware of any instance where a model aircraft operated by a member of the AMA that caused any issues for manned aviation. The most likely short-term impact on this community as the awareness of UASs grows, is that they become mistakenly grouped with uncertified and errant UAS operators, which could threaten their ability to operate as they have safely done for decades. The greatest long-term impact could be a loss of membership due to a demographic shift toward UASs rather than model aircraft. Part 101 strikes a favorable balance for their interests and may explain their relative silence on regulatory issues related to UASs in the last 2 years.

Air Traffic Controllers

Responsible to maintain separation of all aircraft flying under instrument conditions, or within the confines of major airports with an operating control tower, are just over 14,050 Air Traffic Controllers (ATC) (FAA, 2017c). They rely on flight plans, radio calls, standardized procedures, radar, and electronic location transmitting devices on aircraft to maintain safety within the prescribed limits. At the largest airports, ATCs manage 2 to 3 arrivals per minute using several runways, hundreds of taxiways, and parking locations scattered across hundreds of acres of real estate. Their customers range from student pilots to commercial carriers of both passengers and cargo, as well as military, private corporate aircraft, and law enforcement, flying fixed wing and rotary wing aircraft. There is a reason that Air Traffic Controllers are regularly named as one of the most stressful occupations in the world.

UASs flying in or near the airspace that ATCs are responsible for not only add to the complexity of the environment for controllers, but increase the risk to manned aviation. The technology that controllers use to detect manned aircraft, is largely ineffective with UASs. Radar systems are designed to detect large, metallic aircraft, rather than small composite multicopters, and location beacons that integrate with the government owned algorithms of TCAS (Traffic Collision and Avoidance System), are just beginning to get small enough to be onboard larger commercial systems. UASs do not typically file flight plans, few operators have radios to converse with controllers, and standardized flight procedures are not established for any but the most developed UAS operators.

This leaves controllers nearly defenseless. The low flying UASs occupy the same low altitudes that manned aviation must transition for takeoff and landing, which is also statistically the most vulnerable altitudes for fatal accidents, without the additional risk of UASs. Pilots rely on controllers for safe separation, yet in the case of UASs, it is now the pilots who are reporting UAS incursions for controllers to relay to others. This is a similar procedure to what

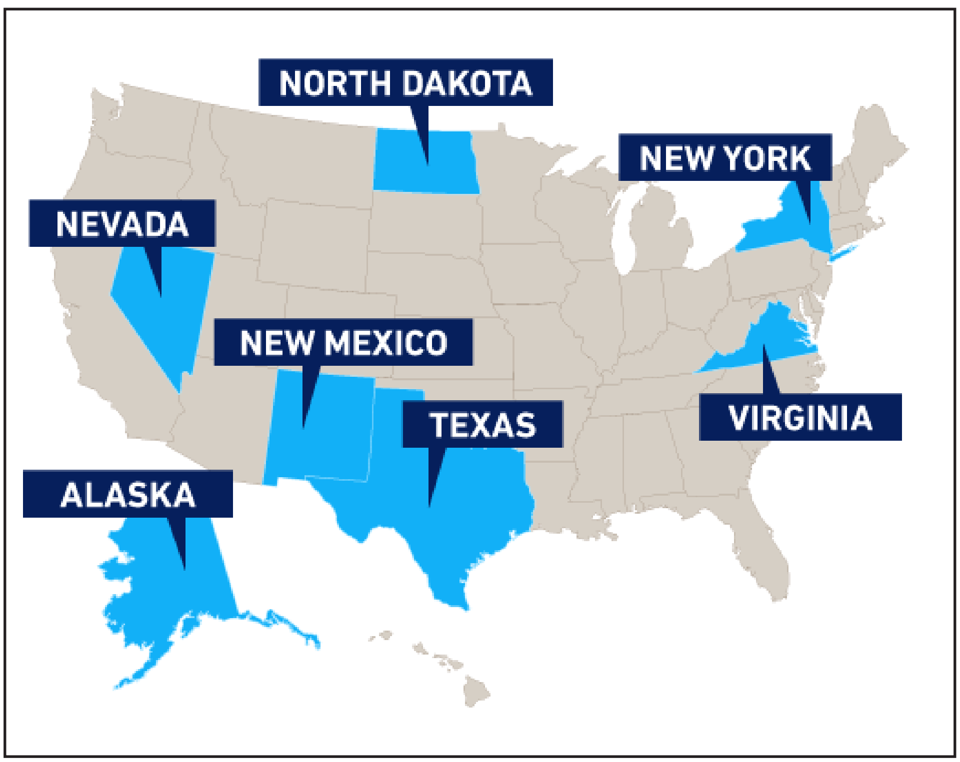

Figure 2: Seven FAA sponsored research locations across the United States (Extracted from https://www.faa.gov/uas/research/test_sites/).

aircrews do when spotting birds or other hazards in-flight, but this hazard is entirely human made and, in most cases, avoidable. Following the FAA regulations and only operating in approved areas would eliminate all but the rarest of safety instances, when a UAS loses contact with the controller and wanders without control.

Researchers

Supporting all of these are the researchers, who test new unmanned technologies for fielding to solve the problems of today. Seven FAA sponsored locations across the United States, run by partnerships with academic, governmental and commercial affiliations, are exploring new technologies to de-conflict the existing manned aviation from the new unmanned craft, detect errant and mal-intentioned systems, and extend the loiter time and range of future UASs (see Figure 2). These locations are run by the North Dakota Department of Commerce, the State of Nevada, New Mexico State University, the University of Alaska Fairbanks, Texas A&M University Corpus Christi, Virginia Polytechnic Institute & State University, and Griffiss International Airport (NY) (FAA, 2017b). In total, "twenty-three of the world's leading research institutions and a hundred leading industry, government partners" are involved in designing, conducting, and reporting on a variety of topics of interest (FAA, 2017b).

Some of the areas of greatest interest to these testing sites includes Beyond Visual Line of Sight (BVLOS) and Detect and Avoid technologies.

In addition to the efforts by the FAA, NASA reached the milestone flight of a UAS in the NAS without a chase aircraft, which was the goal of a 5-year effort, on June 12 of 2018 (Northon, 2018). With a waiver from the FAA, they operated in all classes of airspace all the way up to 20,000 feet. In all known instances, the aircraft detected potential conflicting traffic and relayed that information to the pilot on the ground, with "all test objectives successfully accomplished" (Northon, 2018). The system flown was a larger UAS with sophisticated radar and electronics onboard, which is not available for most small UASs.

Other testing locations exist throughout the country for specialized, industry specific purposes, but are not affiliated with the FAA, and their advancements are difficult to correlate to efforts to integrate UASs into the National Airspace System. Although some groundbreaking work is being done at these sites, they are beyond the scope of this Industry Analysis.

General Public

The relationship between stakeholders can significantly influence the ability of a technology to evolve and succeed. Since "it is possible for minimum quality standards to stop welfare enhancing innovation," a budding industry like UASs, that currently uses aviation regulations built to provide extremely high levels of safety in manned aircraft, could be vulnerable to stifled innovation and growth (Blind, Petersen, & Riillo, 2017). Improperly or incompletely designed and implemented regulations related to UASs could seriously undermine industry growth.

328 million people called the United States home in July of 2018 (U.S. Census Bureau, 2018). Nearly every one of them is impacted directly or indirectly by UASs, as a family member of the over 2.4 million who purchased a UAS in 2017, as one of the approximate 6 million who have at some point in their lives owned a UAS, or the countless others who have seen, or benefited from the services provided by a UAS. National news coverage such as seen on 28 November 2017 on NBC's Nightly News, increases awareness and indicates a significant uptick in concern regarding UASs (Holt, 2017). However, not all of the 328 million are pleased with UASs, and there are issues that society must face in the near future as UASs take their place in society. As issues are settled, they are likely be codified in regulations and laws.

There are issues that society must face in the near future as UASs take their place in society.

In 2016, the FAA started an annual national UAS Symposium focusing on UAS regulation, with the most recent symposium occurring from 6 through 8 March, 2018. This brought over 950 interested representatives from government, industry, and academia together to balance the needs of all stakeholders. The FAA's Acting Director, Acting Deputy Director, Acting Director of Flight Standards, Acting Director of Airports, the Executive Assistant of President and Deputy Unmanned Technology Officer, and CEOs from several companies with a significant interest in UASs all attended. Although not clearly defined, the issues discussed revolved around one of the following categories defined in a literature review by Luppicini and So in 2016.

This literature review lays out eight categories of concern that UASs face (see Figure 3). Although based solely on articles and news stories related to commercial UASs, these reoccurring categories seem to be extremely important. Topics discussed at the symposium, the categories that UAS reporting agencies use for their news stories, and the interviews conducted to support this study all align

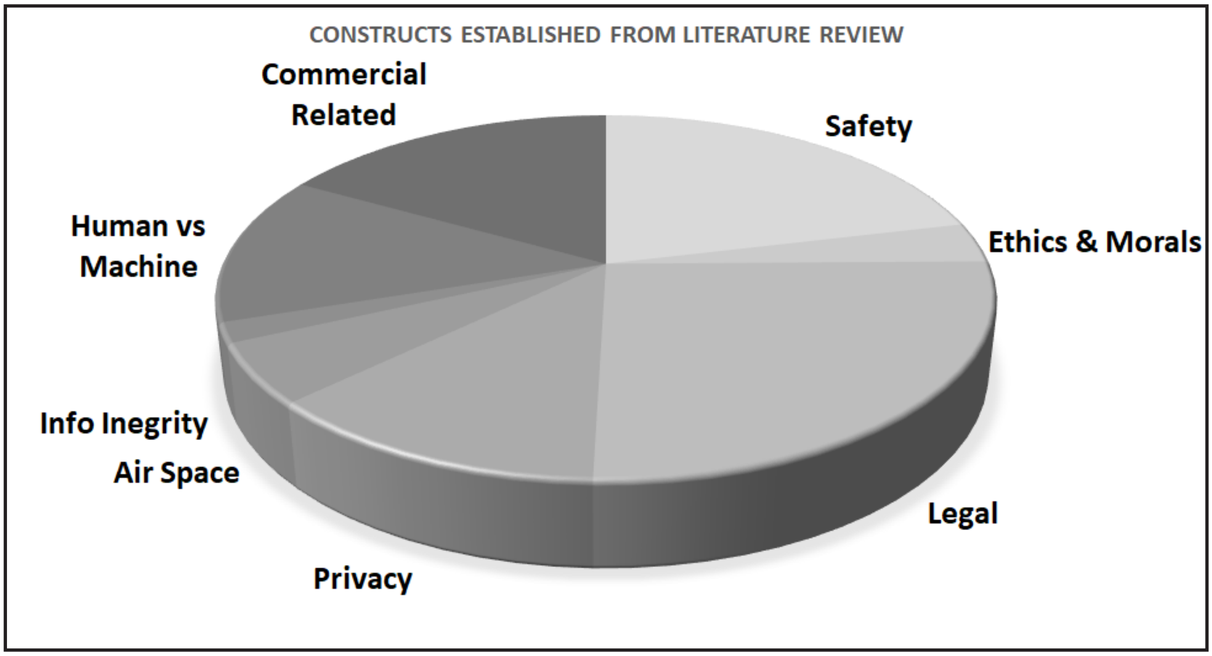

Figure 3: Eight categories of concern that UASs face. Extracted with permission from Luppicini & So (2016).

with this construct: safety, ethics and morals, legal, privacy, airspace, information integrity, human versus machine, and commercial related (Luppicini & So, 2016). This Industry Analysis is not designed to analyze these issues in depth, but they must be mentioned since several of these issues will shape the course of business for UAS operators and manufacturers.

Discussion

The UAS industry is undergoing a rapid succession of change, particularly in the technological and legislative arenas. Although UAS technology was advancing, it is the readily available small UASs built by companies like Parrott and DJI that have upended the environment and forced government into action. Almost weekly a new technology or local ordinance is released, and monthly a major announcement by a significant stakeholder seems to shake up the industry and the assumptions that underlie it. In late 2017, President Trump sent a memo to the Department of Transportation, directing them to make it easier to fly a commercial drone. In March of 2018, the acting director of the FAA announced LAANC, a partnership with industry that completely changed the way Part 107 certified UAS operators received clearance to fly, reducing clearance times from upwards of 4 months, to just minutes. By the time this Industry Analysis is published, many parts are likely to be outdated and will serve more as a historical snapshot of the industry and the status of the challenges faced.

One upcoming legislative piece that may alter or even completely upend the foundations of this study, is the FAA Reauthorization Act of 2018, introduced by Representative Shuster. This act has provisions within that may upend model aircraft exemptions in section 336, levy fees to UAS users to pay for regulatory oversight costs, create an Unmanned Aircraft Traffic Management System (UTM), and updates sections of Part 107 to allow UASs to carry cargo after meeting still to be defined safety requirements (Rupprecht, 2018). Still under review and debate at the time of this paper being written, these provisions may or may not still exist in the final version, and others may be added.

Despite this, the relevancy is still clear as it serves to summarize the industry in its current state and lays out the major challenges that must be overcome to reach full potential. As UAS utility increases and companies and governmental agencies find new uses for them, new challenges will arise, but the issues will likely still fall within one of the eight constructs described in the General Public section above. Many of these challenges will take years to settle, with particular issues like privacy requiring the eventual intervention of the Supreme Court of the United States. This is nothing new, but it is new to UASs.

Helicopters when used for surveillance by law enforcement required a Supreme Court ruling in 1989 to determine if that use complied with the Fourth Amendment dealing with unreasonable search and seizure. The courts found in that instance that ("Florida v. Riley," 1989):

> *Because there is reason to believe that there is considerable public use of airspace at altitudes of 400 feet and above, and because respondent introduced no evidence to the contrary before the state courts, it must be concluded that his expectation of privacy here was not reasonable. However, public use of altitudes lower than 400 feet--particularly public observations from helicopters circling over the curtilage of a home--may be sufficiently rare that police surveillance from such altitudes would violate reasonable expectations of privacy, despite compliance with FAA regulations.*

The ruling is just one example of existing law that will impact how a stakeholder uses UASs and to what extent, and what may need to happen to allow these systems to reach their full business potential. Law enforcement officials are in a precarious situation with UASs as a result of this ruling. The airspace below 400 feet was not used significantly by the public in 1989, but today the proliferation of UASs by the public at these altitudes may have changed the environment enough to overturn that portion of the decision. By the time that the FAA Reauthorization Act of 2018 reaches its final version, this issue may be included, but even then, a final ruling by the Supreme Court will be required to finalize the legality.

As technology becomes more reliable and can prove that safe UAS operations can occur, and as legislative issues are resolved (oftentimes with technological advances that are brought to market by manufacturers), UAS use will become more prevalent. The impact of UASs on the economy and everyday life is nearly impossible to imagine given today's climate and the multitude of challenges that have yet to be solved. What is certain, is that to solve these problems, all of the stakeholders listed in this Industry Analysis must be considered and involved in the process for the UAS Industry to reach its full business potential.

Conclusions

In March, the FAA stated that they estimated that 2 million midsized UASs were in the United States, and the data seems to support this. Estimated sales figures show that 2.4 million UASs for both personal and commercial use were sold in 2017 (Meola, 2017). Many are sub $100 models from the local drugstores or megastores, weigh less than half a pound, and are flown once or twice then forgotten, but over 40% of UAS sales are for those over $300. This means that 960,000 small to mid-sized systems were sold just in 2017. Sales appear to double every year, so in 2016 there would be 480,000, and in 2015--240,000, netting nearly 2 million systems still operational in the United States. If "more than two-thirds (68%) of all drones weighing over 250 grams are purchased for professional purposes," we then have about 1.14 Million UASs for commercial purposes in the United States (Snow, 2017a). In Sept of 2017, the FAA showed just over 100,000 Certified Part 107 pilots, so there are 1.14 Million UASs for commercial purposes, and only 100,000 certified pilots. This is a major issue for the budding and rapidly changing UAS industry.

Commercial aviation is less than 100 years old, and the FAA in its current form, which emphasizes "Safety First, Last, and Always," was realized in 1958 with the passing of the Federal Aviation Act (FAA, 2017a). The culture that developed over 60 years with a focus on safety was not arbitrary, but rather the result of the public's desire to travel or be near aircraft with little fear of injury or death. Professional aviators comply with FAA regulations and maintain a culture that aligns with this desire for safety. If only 100,000 small to medium sized UAS operators are complying with FAA regulations, that then leaves over 1 million UAS pilots flying for commercial purposes that are not complying.

The changes we see today in the UAS Industry, and the pace at which these changes are occurring, would not be possible without small to medium sized UASs, but it is also these UAS operators that fall into the category of non-compliance with FAA regulations. The larger UAS systems and their operators will ultimately benefit from the increased interest in accelerating legislation to allow UASs to operate commercially in the Unites States, but the non-compliant operators also threaten to erase this forward progress with a single accident. Until legislation is solidified and public exposure and opinion is sufficiently positive surrounding commercial UAS operations, this industry remains primed for great growth and success, yet poised for significant restrictions and public scrutiny.

Ultimately, the laws are only as good as the enforcement actions taken to reinforce them. The preliminary interviews conducted that started this project indicated that there was insufficient enforcement of existing laws, so it would be unreasonable to expect the introduction of new laws to solve all the issues. It is the professional aviators who follow the laws that suffer in the short-run, as unlicensed "fly-by-night" individuals undercut legitimate businesses, but they are also the ones who safely provide complete UAS solutions that contribute reliable data and real value to consumers. They are the ones who are partnering with the FAA to rewrite legislation to make safe, legal operations possible. In the long-run, it is the professional aviators who will be able to leverage the full capability of UASs for the greatest benefit, and will see exponential growth in a yet infantile industry.

References

112th Congress (2011-2012). (2012). *H.R.658 - FAA Modernization and Reform Act of 2012.*

Academy of Model Aeronautics. (n.d.). *Headquarters staff.* Retrieved from http://www.modelaircraft.org/aboutama/organization/hqstaff.aspx

Aircraft Owners and Pilots Association. (2017). *2018 Flight training college aviation directory.* Retrieved from http://download.aopa.org/FTmagazine/1712f_collegedirectory.pdf

Aircraft Owners and Pilots Association. (2018). *Find a flight school.* Retrieved from https://www.aopa.org/learntofly/school/index.cfm

Atherton, K. D. (2016). *Read Nikola Tesla's drone patent... from 1898.* Retrieved from https://www.popsci.com/nikola-tesla-patented-drone-controls-in-1898

Blind, K., Petersen, S., & A. F. Riillo, C. (2017). The impact of standards and regulation on innovation in uncertain markets. *Research Policy,* 249-264.

Chamata, J. E. (2017). Convergence of the Unmanned Aerial Industry. *Scientific Research Publishing,* 175-186.

Chepkemoi, J. (2017). How many colleges are in the US? *World Atlas.* Retrieved from https://www.worldatlas.com/articles/how-many-colleges-are-in-the-us.html

ConstructConnect Project Research. (2017). *20 Major upcoming private and government office building construction projects – U.S. – November 2017.* Retrieved from https://www.constructconnect.com/blog/economy/20-major-upcoming-private-government-office-building-construction-projects-u-s-november-2017/

Contribution of general aviation to the US economy in 2013. (2015). Retrieved from https://www.nbaa.org/business-aviation/2015-general-aviation-contribution-to-US-economy.pdf

Creedy, A. (2018). *Bellevue University to offer Unmanned Safety Institute's drone training courses.* Retrieved from http://www.bellevue.edu/about/media-relations/stories/2018-05-Unmanned-Safety-Instutute-Drone-Training-Courses

Day, K. (2012). *Tower climbing deaths.* Retrieved from https://www.towerclimber.com/tower-climbing-deaths/

DJI. (2018). *Products.* Retrieved from https://www.dji.com/products

Dowling, S. (2017). *The plane so good it's still in production after 60 years.* Retrieved from http://www.bbc.com/future/story/20170302-the-plane-so-good-its-still-in-production-after-60-years

Embry Riddle Aeronautical University. (2018). *Enrollment.* Retrieved from https://news.erau.edu/media-resources/facts-and-figures/enrollment/

FAA. (2017a). *A brief history of the FAA*. Retrieved from https://www.faa.gov/about/history/brief_history/

FAA. (2017b). *UAS test sites.* Retrieved from https://www.faa.gov/uas/research/test_sites/

FAA. (2017c). *Air traffic by the numbers*. Retrieved from https://www.faa.gov/air_traffic/by_the_numbers/

FAA. (2017d). *The economic impact of civil aviation on the U.S. economy.* Retrieved from https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf

FAA. (2018a). *Section 333*. Retrieved from https://www.faa.gov/uas/beyond_the_basics/section_333/

FAA. (2018b). *UAS sightings report*. Retrieved from https://www.faa.gov/uas/resources/uas_sightings_report/

FAA. (2018c). *Press release – FAA hits 100k remote pilot certificates issued*. Retrieved from https://www.faa.gov/news/update

FAA UAS Symposium. (2018). Retrieved from https://www.faa.gov/uas/resources/event_archive/2018_uas_symposium/

Federal Aviation Administration. (2018). *Electronic code of federal regulations.* Retrieved from https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=7b2be47d0f0b0f80a9b50b8f55ebb950&r=SECTION&n=14y3.0.1.1.7.20.3.20

Federal Reserve Bank. (2018). *Real value added by private industries: Construction.* Retrieved from https://fred.stlouisfed.org/series/RVAC

Fitzpatrick, A. (2018). *Watch as nearly 1000 drones come together to make Time's new cover.* Retrieved from http://time.com/5294789/time-drone-cover-video/

Florida v. Riley, 488 U.S. 445, No. 87-764 (1989). Retrieved from https://supreme.justia.com/cases/federal/us/488/445/

Glaser, A. (2017). *Police departments are using drones to find and chase down suspects.* Retrieved from https://www.recode.net/2017/4/6/15209290/police-fire-department-acquired-drone-us-flying-robot-law-enforcement

Grigonis, H. (2017). *As Parrot's drone sales revenue loses altitude, company announces layoffs.* Retrieved from https://www.digitaltrends.com/cool-tech/parrot-announces-layoffs-drone-division/

Harry Ransom Center. (n.d.). *The first photograph.* Retrieved from http://www.hrc.utexas.edu/exhibitions/permanent/firstphotograph/

Hartsfield-Jackson Atlanta International Airport. (2018). *ATL fact sheet.* Retrieved from http://www.atl.com/about-atl/atl-factsheet/

Henderson, B. (2018, February 18). Did a drone take down SC helicopter? The answer could make history. *The Charlotte Observer.* Retrieved from https://www.charlotteobserver.com/news/local/article200475419.html

Hoge, P. (2013). *Chris Anderson lands $30 million for 3D robotics drones.* Retrieved from https://www.bizjournals.com/sanfrancisco/blog/2013/09/chris-anderson-3d-robotics-true-ventures.html?page=all

Holt, L. (2017). *Feds plan mandatory registration of all unmanned drones.* Retrieved from https://www.nbcnews.com/nightly-news/video/feds-plan-mandatory-registration-of-all-unmanned-drones-547500099581

Huerta, M. (2017). *Unmanned aircraft systems symposium opening remarks.* Retrieved from https://www.faa.gov/news/speeches/news_story.cfm?newsId=21554

Johnson, B. (2010, January 6). CES: iPhone-controlled drone unveiled at tech show curtain-raiser. *The Guardian.* Retrieved from https://www.theguardian.com/technology/2010/jan/06/ces-iphone-controlled-drone

Juang, M. (2018). *How drone photography is carving a niche in construction.* Retrieved from https://www.cnbc.com/2018/07/08/how-drone-photography-is-carving-a-niche-in-construction.html

Kaplan, K. (2016). *Disney makes history with first U.S. light show powered by 300 Intel drones.* Retrieved from https://iq.intel.com/drone-light-show-takes-disney-world-visitors-future/

Kratsios, M. (2018, March 6). *FAA UAS Symposium.* (2018). Retrieved from https://www.faa.gov/uas/resources/event_archive/2018_uas_symposium/

Kirk, L., Marshall, D., Trapnell, B., & Frushour, G. (2009). *Unmanned aircraft system regulation review.* Retrieved from http://www.tc.faa.gov/its/worldpac/techrpt/ar097.pdf

Lillian, B. (2018). *Xcel Energy ok'd to routinely fly drones beyond line of sight.* Retrieved from https://unmanned-aerial.com/xcel-energy-okd-to-routinely-fly-drones-beyond-line-of-sight

Lisberg, A. (2018). *Public safety drones save four lives in one day.* Retrieved from https://www.dji.com/newsroom/news/drones-save-lives-public-safety-search-rescue-four-one-day

Luppicini, R., & So, A. (2016). A technoethical review of commercial drone use in the context of governance, ethics, and privacy. *Science Direct,* 109-119.

Marsh, A. (2015). *Hourly operating costs of 45 jets compared.* Retrieved from https://www.aopa.org/news-and-media/all-news/2015/november/16/hourly-operating-costs-of-45-jets-compared

McNabb, H. (2016). *DroneLife ranked number one commercial drone news site worldwide.* Retrieved from https://dronelife.com/2016/02/17/dronelife-com-number-one-global-leader-for-commercial-drone-news-and-services/

McNabb, M. (2017). *How many farmers are really using drones – And who's flying?* Retrieved from https://dronelife.com/2017/04/17/many-farmers-really-using-drones-whos-flying/

Meola, A. (2017). *Drone market shows positive outlook with strong industry growth and trends.* Retrieved from https://www.businessinsider.com/drone-industry-analysis-market-trends-growth-forecasts-2017-7

Morgan, T. (2014, April 21). *Agriculture drone business takes off.* Retrieved from US Farm Report: https://www.agweb.com/article/agriculture_drone_business_takes_off_naa_tyne_morgan/

National Air Traffic Controllers Association. (2018). *Aviation facts.* Retrieved from https://www.natca.org/index.php/acronyms-breakdown/facts-sheet

National Business Aviation Assoc. (2012). *President Obama signs FAA Reauthorization Bill into law.* Retrieved from https://www.nbaa.org/advocacy/issues/modernization/20120215-obama-signs-faa-reauthorization-bill-into-law.php

Nicas, J., & Murphy, C. (2014, November 10). Who builds the world's most popular drones? *The Wall Street Journal.* Retrieved from https://www.wsj.com/articles/who-builds-the-worlds-most-popular-drones-1415645659

Northon, K. (2018). *NASA flies large unmanned aircraft in public airspace without chase plane for first time.* Retrieved from https://www.nasa.gov/press-release/nasa-flies-large-unmanned-aircraft-in-public-airspace-without-chase-plane-for-first

Pedraza, J. M. (2013). *UND expected to play major role in FAA-approved program to advance UAS use.* Retrieved from University of North Dakota: http://www1.und.edu/features/2013/12/uas.cfm

Professional Aerial Photographers Association. (n.d.). *History of aerial photography.* Retrieved from http://professionalaerialphotographers.com/content.aspx?page_id=22&club_id=808138&module_id=158950

Research Centre of the Palace of Versailles. (n.d.). *The first hot air balloon flight.* Retrieved from http://en.chateauversailles.fr/discover/history/first-hot-air-balloon-flight

Rupprecht, J. (2018). *FAA Reauthorization Act of 2018 & Drones*. Retrieved from https://jrupprecht-law.com/faa-reauthorization-act-of-2018

Sabatini, N. (2007). *Unmanned aircraft operations in the national airspace system*. Retrieved from https://www.faa.gov/uas/media/frnotice_uas.pdf

Scott, M. (2017). *Premium drones drive steady sales, while lower cost drones fly off shelves during the holidays*. Retrieved from https://www.npd.com/wps/portal/npd/us/news/press-releases/2017/us-drone-sales-more-than-double-year-over-year-with-a-strong-start-to-2017-reports-npd/?utm_source=web-us-homepage&utm_medium=press-releases&utm_campaign=U.S.%20Drone%20Sales%20More%20Than%20D

Shepardson, D. (2018). *2017 Safest year on record for commercial passenger air travel: Groups*. Retrieved from https://www.reuters.com/article/us-aviation-safety/2017-safest-year-on-record-for-commercial-passenger-air-travel-groups-idUSKBN1EQ17L

Snow, C. (2017a). *Five biggest commercial drone trends of 2017 and the challenges ahead*. Retrieved from http://droneanalyst.com/2017/12/19/five-biggest-commercial-drone-trends-of-2017-and-the-challenges-ahead

Snow, C. (2017b). New research: 2017 Drone market sector report. Retrieved from http://droneanalyst.com/2017/09/18/new-report-unveils-drone-industry-market-share-figures

Spencer, D. (2008). *A survey of issues related to integrating unmanned aerial systems (UAS) into the national airspace system (NAS)*. Grand Forks, North Dakota: University of North Dakota.

Statista. (2018). *Highway construction in the U.S. - Statistics & facts*. Retrieved from https://www.statista.com/topics/974/construction/

U.S. Census Bureau. (2018). *U.S. and world population clock*. Retrieved from https://www.census.gov/popclock/

United States Government Accountability Office. (2014). *GAO-14-232: Current and future availability of airline pilots*. Retrieved from https://www.gao.gov/assets/670/661243.pdf

Unmanned Systems Technology. (2018). *Find a supplier*. Retrieved from http://www.unmannedsystemstechnology.com/supplier-directory/

Wall, R. (2003). *Under scrutiny*. Retrieved from http://aviationweek.com/toboggan/revalidate/4263201?destination=node%2F475221

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