DRONES: HOW THEY WORK, APPLICATIONS, AND LEGAL ISSUES

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I. INTRODUCTION

In 2001, a U.S. military drone, Predator, became the first weapon to stalk and kill an individual on the other side of the planet.[1] Controlled from the Central Intelligence Agency (CIA) campus in Virginia, the Predator hovered over a compound in Afghanistan, which housed Mullah Mohammed Omar, an ally of Osama Bin Laden.[2] The Predator drone then followed a convoy and fired missiles at the target.[3] While not all drones are designed with deadly force in mind, the Predator drone demonstrates the striking extent of drone capabilities.

Drones have become increasingly prevalent throughout the twenty-first century, with their utility spanning from defense applications to recreational filmography. At its core, a drone is an aerial vehicle that flies without a physical person aboard.[4] In 1946, the name "drone" was first

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[1] Daniel Terdiman, *The History of the Predator, the Drone That Changed the World (Q&A)*, CNET (Sept. 20, 2014, 4:00 AM), https://www.cnet.com/news/the-history-of-the-predator-the-drone-that-changed-the-world-q-a/ [https://perma.cc/4UE6-6M5B].

[2] Richard Whittle, *How We Missed Mullah Omar*, POLITICO (Sept. 16, 2014), https://www.politico.com/magazine/story/2014/09/how-we-missed-mullah-omar-111026 [https://perma.cc/D4K8-DBHU].

[3] *Id*.

[4] Nidhi Subbaraman, *Don't Call 'Em Drones: The Wide World of Unmanned Flying Machines*, NBC NEWS (Mar. 15, 2013, 4:42 AM), https://www.nbcnews.com/technolog/dont-call-em-drones-wide-world-unmanned-flying-machines-1C8857699 [https://perma.cc/X7Z4-USVW].

applied to a radio-controlled aircraft—taking its lineage from the term for a male bee.[5]

This paper discusses how drones work, their applications, and legal issues. Further history of drones is presented in Section II. Section III discusses the functionality and operations of drones, while Section IV delineates the different types of drones. Drone applications are discussed in Section V followed by legal issues in Section VI. Section VII concludes.

II. HISTORY OF DRONES

Although drones have gained attention recently, their origins stretch back over a century. One hundred and twenty years ago, Nikola Tesla controlled an unmanned boat using a remote and radio frequency signals.[6] Drones first became airborne in 1940 when remote-controlled target aircrafts were used to train anti-aircraft gunners for World War II.[7] In 1995, the U.S. military began using the lethal Predator[8]—just six years before it was used to kill Al Qaeda forces at Mullah Mohammed Omar's compound.[9]

While most of drone history is rooted in military applications, commercial use is now becoming popularized. The French company Parrot released their "AR.Drone" in 2010 as the "first commercially successful ready-to-fly consumer drone."[10] Just eight years later, in 2018, the Federal Aviation Administration (FAA) announced that the number of commercially registered drones topped one million.[11] In 2017, it was estimated that about three hundred companies were investing in drones, and the market could reach $46 billion by 2026.[12]

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[5] *Drones Are Everywhere Now But How Did They Get Their Name?*, MERRIAM-WEBSTER DICTIONARY, https://www.merriam-webster.com/words-at-play/how-did-drones-get-their-name [https://perma.cc/B2ZA-G6DZ].

[6] Clay Dillow, *A Brief History of Drones*, FORTUNE (Oct. 9, 2014), http://fortune.com/2014/10/09/a-brief-history-of-drones/ [https://perma.cc/S98L-8RPN].

[7] *Id*.

[8] *See Id.*

[9] *See* Terdiman, *supra* note 1.

[10] Ed Darack, *A Brief History of Quadrotors*, AIR & SPACE MAG. (May 19, 2017), https://www.airspacemag.com/daily-planet/brief-history-quadrotors-180963372/ [https://perma.cc/6QY4-3L6E].

[11] *FAA Drone Registry Tops One Million*, U.S. DEP'T OF TRANSP. (Jan. 10, 2018), https://www.transportation.gov/briefing-room/faa-drone-registry-tops-one-million [https://perma.cc/RCL9-U5FY].

[12] Richard Levick, *Drone Industry Just Beginning to Take Off*, FORBES (May 15, 2018, 12:44 PM), https://www.forbes.com/sites/richardlevick/2018/05/15/drone-industry-just-beginning-to-take-off/#1f05e3a172bc [https://perma.cc/77SK-UW5E].

III. FUNCTIONALITY AND OPERATIONS OF DRONES

The most common forms of drones contain a set core of components. These include a flight controller, sensors, and an energy source.

The flight controller is the drone's brain and is central to the control of the drone.[13] The flight controller receives inputs from radio frequency signals from a user as well as signals from various onboard sensors.[14] Accelerometer sensors can be used to determine the position and orientation of the drone in flight,[15] while inertial measurement units sense changes in the drone's direction.[16] Other sensors may be used to track GPS location[17] or may indicate battery level.[18] All of these sensors feed into the flight controller which uses the sensor signals to determine the speed of the motors in order to control the drone.[19]

The energy sources for drones can vary based on the type of drone in use. In commercial drones, lithium polymer (LiPo) batteries are typically used to power drones because they have high capacities and can deliver the high discharge rate necessary for the drone propellers.[20] LiPo batteries are safe if properly handled; however, they can present a dangerous risk of explosion if a battery is punctured.[21] Alternatively, industrial or military drones may draw power from solar panels or

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[13] *See* Fintan Corrigan, *Quick Drone Parts Overview along with Handy DIY Tips*, DRONEZON (Jan. 20, 2018), https://www.dronezon.com/learn-about-drones-quadcopters/drone-components-parts-overview-with-tips/ [https://perma.cc/3DBH-47N4].

[14] *See Id*.

[15] Chris Winkler, *How Many Sensors Are in a Drone, and What Do They Do?*, SENSORS MAG. (July 22, 2016, 1:00 AM), https://www.sensorsmag.com/components/how-many-sensors-are-a-drone-and-what-do-they-do [https://perma.cc/2PC3-ATMZ].

[16] *Id*.

[17] *See* Corrigan, *supra* note 13; *Satellite Navigation - GPS - How It Works*, FAA (June 15, 2015, 2:24 PM), https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/gps/howitworks/ [https://perma.cc/RG3C-PHTW].

[18] *See* Corrigan, *supra* note 13.

[19] *Id*.

[20] *The Advanced Quadcopter Battery Guide*, DRONEOMEGA, https://www.droneomega.com/quadcopter-battery-guide/ [https://perma.cc/RL6M-JJAX].

[21] *Id*.

gasoline.[22] The military Predator drone contains fuel tanks capable of storing 600 pounds of high-octane fuel—enabling 24-hour flights.[23]

Drone operations can be fairly autonomous by programming flight paths in advance in place of real-time control. The preprogrammed flight path can be determined by specifying waypoints to travel through, as well as the location and hover duration at each point.[24] For example, if a user wants a drone to fly over a golf course, the user can specify eighteen waypoints for eighteen golf holes. The first waypoint corresponds to the location of the first hole with a height value and hover time duration, while the second waypoint would correspond to the second hole, and so on. The programmed flight path information is stored in the drone controller.[25] Then, once launched, the drone would fly to the first hole using the location data and follow the programmed path. In addition to the autonomous movement, certain drones enable a user to control flights manually by sending the flight control information in real time. This control information is typically sent to drones via radio signal.

IV. TYPES OF DRONES

Most drones take the form of two popular designs: multi-rotor and fixed-wing. Multi-rotor designs function like helicopters, and fixed-wing designs operate like airplanes. These two designs provide different benefits due to the way they maintain flight.

A multi-rotor drone, like the name implies, uses multiple rotors where each rotor consists of two or more rotor blades.[26] The drone contains a motor which rotates the attached rotor blades. In a multi-rotor drone, the rotors are commonly grouped in pairs with two, four, six, or

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[22] Brian Heater, *MIT's Gas-Powered Drone Is Able to Stay in the Air for Five Days at a Time*, TECHCRUNCH, https://techcrunch.com/2017/06/27/mits-gas-powered-drone-is-able-to-stay-in-the-air-for-five-days-at-a-time/ [https://perma.cc/Y99V-PYC4].

[23] Robert Valdes, *How the Predator UAV Works*, HOWSTUFFWORKS, https://science.howstuffworks.com/predator1.htm [https://perma.cc/ATC4-TSKG].

[24] *See* Andrew Hansen, *Using Waypoints to Do More with Your Drone*, AUTEL ROBOTICS (Dec. 21, 2016), https://www.autelrobotics.com/blog/using-waypoints-to-do-more-with-your-drone/ [https://perma.cc/9U46-WUD3].

[25] ArduPilot Dev Team, *Planning a Mission with Waypoints and Events*, ARDUPILOT, http://ardupilot.org/copter/docs/common-planning-a-mission-with-waypoints-and-events.html [https://perma.cc/7V7U-SZGL].

[26] *See* Rhett Allain, *How Do Drones Fly? Physics, of Course!*, WIRED (May 19, 2017, 8:00 AM), https://www.wired.com/2017/05/the-physics-of-drones/ [https://perma.cc/TFR3-ESZV].

more rotors.[27] The drone generates the force required to lift the drone upward by the rotating blades. The faster the blades rotate, the more force generated. The absolute and relative speeds among the blades determine the movement of the drone, where a mismatch in the speeds allows the drone to turn. As the rotors have sharp edges and rotate at very high speeds,[28] they can be very dangerous.[29] Therefore, some drones are manufactured with guards around their rotors for safety.[30]

Fixed-wing drones operate like airplanes and, unlike the multi-rotor drone, rely on wings in addition to one or more propellers.[31] The fixed-wing drone's upward lift is provided by the fixed wings mimicking a regular airplane.[32] Spatial control comes from mechanisms on the wing and body, which "traditionally consist of ailerons, an elevator, and a rudder."[33] The advantages of the fixed-wing drone include faster speed and longer flying time,[34] but they require runways to take off to reach enough speed to become airborne. While some fixed-wing drones can fly up to twenty-five hours at a time, like an airplane, they cannot stay at a set position in the air.[35] If monitoring a fixed point is needed, a fixed-wing drone must circle around that point. Therefore, these drones are generally used for applications that take advantage of their distance and flight-time, such as the environmental monitoring of a forest and agriculture.

Compared to the fixed-wing drones, multi-rotor drones have shorter flights and range. However, the advantages of the multi-rotor drone come from its low cost, [36] easy control,[37] and runway-free takeoff.[38]

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[27] Jonathan Feist, *How Many Propellers Does Your Drone Need?*, DRONERUSH (Mar. 4, 2018), https://www.dronerush.com/propellers-drone-need-science-of-flight-10733/ [https://perma.cc/RG3T-VN3J].

[28] *See Part 1: Propeller RPM and Pitch*, QUAD STAR DRONES, https://quadstardrones.com/part-1-propellers/ [https://perma.cc/P7GS-UNLS].

[29] *See* Mark LaFay, *How to Avoid Propeller Injuries When Using Your Drone*, DUMMIES, https://www.dummies.com/consumer-electronics/drones/how-to-avoid-propeller-injuries-when-using-your-drone/ [https://perma.cc/G4W3-4Y9B].

[30] *Id.*

[31] *Module 1 Introduction and Applications*, DRONAAVIATION, http://www.dronaaviation.com/learn-module-1/ [https://perma.cc/AL9A-V9UJ].

[32] *See id*.

[33] *Id*.

[34] Matthew Johnson, *Fixed-Wing vs. Multi-Rotor Drones: Which Is the Best?*, M3 AERIAL PRODUCTIONS (June 16, 2017), https://www.m3aerial.com/blog/2017/6/14/fixed-wing-vs-multi-rotor-drones-which-is-the-best [https://perma.cc/4ZZH-PACE].

[35] *See* Alberto Cuadra & Craig Whitlock, *How Drones Are Controlled*, WASH. POST (June 20, 2014), https://www.washingtonpost.com/wp-srv/special/national/drone-crashes/how-drones-work/ [https://perma.cc/DVQ6-YZR8].

[36] Johnson, *supra* note 34.

[37] *Id*.

[38] *Module 1 Introduction and Applications*, *supra* note 31.

The traveling speed is slower for a multi-rotor drone, and the distance it can travel is shorter because it needs to use energy to push air down to stay afloat.[39] Therefore, these drones excel in applications that require precise control over a small coverage area such as wedding videography,[40] food delivery,[41] or the delivering of a lifesaver to someone drowning.[42]

V. APPLICATIONS

Drones have become more popular recently, with many individuals and organizations utilizing the technology.[43] Drone utility includes a broad spectrum of applications, from military and police use, to recreational, commercial, and even criminal uses.

One of the most publicized areas is the use of drones by governmental entities such as military and police law enforcement.[44] The military has utilized drones in the past to find and assassinate Al Qaeda forces abroad.[45] Domestically, the United States Customs and Border Protection is currently using drones to monitor borders and intercept trafficked drugs.[46] On a more localized level, police and fire departments are using drones for various purposes, including rescue operations,[47]

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[39] Johnson, *supra* note 34.

[40] DJI Support, *Breathtaking Drone Wedding Photography: 2019 Edition*, DJI (Feb. 15, 2019), https://store.dji.com/guides/drone-wedding-photography/ [https://perma.cc/ 723A-YGM2].

[41] Daniel White, *Google and Chipotle Are Testing Drone Burrito Delivery at Virginia Tech*, TIME (Sept. 14, 2016), http://time.com/4493291/google-tests-drone-deliveries-virginia-tech/ [https://perma.cc/7FCU-BBSH].

[42] Evan Ackerman, *Useful and Timely Delivery Drone Drops Life Preserver to Australian Swimmers*, IEEE SPECTRUM (Jan. 22, 2018), https://spectrum.ieee.org/automaton/robotics/drones/useful-and-timely-delivery-drone-drops-life-preserver-to-australian-swimmers [https://perma.cc/6QZU-CSSX].

[43] Christina Mercer, *How Are Drones Used? Top Companies Using Drones Right Now*, TECHWORLD (Sept. 3, 2018), https://www.techworld.com/picture-gallery/apps-wearables/best-uses-of-drones-3605145/ [https://perma.cc/6QZU-CSSX].

[44] *See* Terdiman, *supra* note 1; Justin Bachman, *How U.S. Police Departments Are Using Drones*, DAILY HERALD (Apr. 15, 2017), https://www.dailyherald.com/article/20170415/business/170419246/ [https://perma.cc/EG5M-BBTW].

[45] *See* Terdiman, *supra* note 1.

[46] *Id.*

[47] Frank Taylor, *Police Use of Drones Expands Rapidly in North Carolina*, CAROLINA PUB. PRESS (Apr. 18, 2018), https://carolinapublicpress.org/27761/police-use-of-drones-expands-rapidly-in-nc/ [https://perma.cc/E8KZ-K98G]; Heater, *supra* note 22; Eliott C. McLaughlin, *As FBI Offers $10,000 Reward, Missing Autistic Boy's Father Blames Himself*, CNN (Sept. 26, 2018), https://www.cnn.com/2018/09/26/us/north-carolina-missing-child-autism/index.html [https://perma.cc/4SHV-PYD5]; Madeline Holcombe, *Rescuers Were Combing the Woods When They Heard the Missing 3-Year-Old Boy Call*

traffic management,[48] crime-scene photography,[49] and aerial surveillance of fires.[50]

Outside of the realm of governmental use, the most popular personal uses focus on recreational photography and videography.[51] Drone photos are appealing because the aerial shots from the sky provide new perspectives to familiar landscapes.[52] Outside of photography, drone racing, where drones fly at up to eighty miles per hour, is a new sport that attracts thousands of fans at racing events.[53]

Commercial uses include photography, video, agriculture, architecture, delivery, and environmental monitoring.[54] Full operation of Amazon Prime Air is still in the future.[55] Amazon Prime Air is a quick package delivery service that delivers packages in thirty minutes or less

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Out for His Mom, CNN (Jan. 25, 2019), https://www.cnn.com/2019/01/25/us/missing-boy-casey-hathaway-found/index.html [https://perma.cc/2XMW-HRN5]; Malek Murison, *DJI: Drones Rescued More Than 65 People in the Last Year*, DRONELIFE (Apr. 30, 2018), https://dronelife.com/2018/04/30/dji-drones-rescued-people/ [https://perma.cc/ZKH4-CD8E].

[48] Bachman, *supra* note 44.

[49] *Id*.

[50] *Id*.

[51] *See* Andrew Meola, *Here's How the U.S. Government Can Accelerate Drone Deliveries*, BUS. INSIDER (Mar. 22, 2016, 1:15 PM), https://www.businessinsider.com/us-government-regulations-can-speed-delivery-drones-for-amazon-prime-air-2016-3 [https://perma.cc/TW9Y-NJ83].

[52] Will Coldwell, *High Times: The Rise of Drone Photography*, GUARDIAN (June 17, 2017), https://www.theguardian.com/travel/2016/jun/17/why-drone-photography-offers-a-different-view-of-travel [https://perma.cc/ZVE2-CYRD]; *see* Sarah Polger, *Dramatic Photos of Our World From Above*, NATIONAL GEOGRAPHIC (Apr. 13, 2018), https://www.nationalgeographic.com/travel/features/photography/dramatic-drone-photos-world-from-above/ [https://perma.cc/X6PF-DZYY].

[53] *Drone Racing Pilots Battle It Out for $100,000 Prize*, CNN (Sept. 19, 2018 11:53 AM), https://www.cnn.com/2018/09/19/sport/drone-racing-league-finals-spt-intl/index.html [https://perma.cc/UY8X-7AEY]; Erin Carson, *Drone Racing Gets Off the Ground*, CBS NEWS (Mar. 31, 2017), https://www.cbsnews.com/news/drone-racing-gets-off-the-ground/ [https://perma.cc/TX79-C4Y6].

[54] Adam C. Uzialko, *10 Cool Commercial Drone Uses Coming to a Sky Near You*, BUS. NEWS DAILY (May 10, 2018, 8:50 AM), https://www.businessnewsdaily.com/9276-commercial-drones-business-uses.html [https://perma.cc/6U5B-V5D8].

[55] Amazon, *Amazon Prime Air's First Customer Delivery*, YOUTUBE (Dec. 14, 2016), https://www.youtube.com/watch?v=vNySOrI2Ny8 [https://perma.cc/F6YP-5L57]; Sally French, *Amazon Left Off Government's First List of Companies Approved for Drone Package Delivery*, MARKETWATCH (May 9, 2018, 6:53 PM), https://www.marketwatch.com/story/amazon-left-off-governments-first-list-of-companies-approved-for-drone-package-delivery-2018-05-09 [https://perma.cc/4X2C-X5KH].

using drones.[56] Amazon plans to deploy the service when they obtain regulatory support.[57]

Drone taxis are currently under development.[58] A drone taxi is a regular drone, except that it carries one or more people. After a passenger chooses a destination, the drone would fly to the destination automatically. A Chinese company, Ehang, developed a drone taxi after over a thousand test flights as a new form of aerial transport.[59] Ehang's drone taxi allows passengers to select any destination within ten miles of its launch point.[60] Volocopter, a German drone taxi company, also demonstrated a five-minute flight in Dubai—a city which hopes to be the first to provide drone taxi service.[61] Boeing, known as the world's largest aerospace company, also joined the drone taxi race by completing a short flight of under one minute.[62] The advantages of the drone taxi include a short travel time and no need for a taxi driver. However, the disadvantages include higher risk due to the drone's airborne nature and the infancy of the technology, the relatively short travel distance, and the need for a landing space.

While there are many legitimate uses for drone technology, drones are now also assisting perpetrators of drug crimes. For example, drone delivery capabilities have been used to transport illicit drugs into prisons.[63] In November 2017, border patrol agents spotted thirteen drones suspected

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[56] *Amazon Prime Air*, https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011 [https://perma.cc/E9KA-T3VP].

[57] *Id*.

[58] *See* Marco Margaritoff, *Watch the Ehang 184 Passenger Drone Successfully Taxi Someone Around*, DRIVE (Feb. 5, 2018), http://www.thedrive.com/aerial/18261/watch-the-ehang-184-passenger-drone-successfully-taxi-someone-around [https://perma.cc/6Z3N-SG3J].

[59] *Id*.

[60] *Id*.

[61] *See* Noah Browning, *Dubai Starts Tests in Bid to Become First City with Flying Taxis*, REUTERS (Sept. 25, 2017, 12:14 PM), https://www.reuters.com/article/us-emirates-dubai-drones/dubai-starts-tests-in-bid-to-become-first-city-with-flying-taxis-idUSKCN1C0232 [https://perma.cc/H9ZR-Z6HB].

[62] Matt McFarland, *Boeing's First Autonomous Air Taxi Flight Ends in Fewer Than 60 Seconds*, CNN (Jan. 23, 2019), https://www.cnn.com/2019/01/23/tech/boeing-flying-car/index.html [https://perma.cc/L7JL-CYUJ].

[63] Bryna Godar, *Legislators Seek $5,000 Fine for Flying Drones over Prisons*, J. SENTINEL (Jan. 24, 2016), http://archive.jsonline.com/news/statepolitics/legislators-seek-5000-fine-for-flying-drones-over-prisons-b99657564z1-366373051.html/ [https://perma.cc/3LSX-VK9D]; Tilly Rubens, *Drug-Smuggling Drones: How Prisons Are Responding to the Airborne Security Threat*, IFSEC GLOB. (Feb. 8, 2018), https://www.ifsecglobal.com/drug-smuggling-drones-prisons-airborne-security-threat/ [https://perma.cc/K7FJ-QV5L]; BBC News, *Drone Delivers Drugs & Mobiles to London Prisoners - BBC News*, YOUTUBE (May 16, 2016), https://www.youtube.com/watch?time_continue=52&v=1Qr8JYi5XEA [https://perma.cc/KB3A-NLDE].

of carrying drugs across one section of the U.S.-Mexico border during just one, four-day period.[64] U.S. agents believe the cartels are aware that the U.S. lacks the ability to detect and intercept in-flight drones.[65] While there are several methods to detect drones, the methods are only effective in short ranges.[66] U.S. Customs and Border Protection has tried a few of these detection systems before and is currently trying another system in Arizona.[67] Even in instances where drones can be detected, the technology to stop them mid-flight are mostly ineffective.[68] Weapons have been developed and designed to shoot down drones, but they are limited to a range of about one hundred meters.[69] Specially trained eagles have been used to capture drones by Dutch Police, but the program was cancelled due to high costs, small demand, the danger to the eagles, and the potential danger of eagles to the public.[70]

VI. LEGAL ISSUES

Drones can crash from the sky and cause unintended damage as a result of failure or operational errors.[71] When there is harm to individuals or to property,[72] lawsuits and legal issues frequently follow.[73] As a result

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[64] Stephen Dinan, *13 Drones in Four Days: How Drug Smugglers Are Using Technology to Beat Border Patrol*, WASH. POST (Jan. 2, 2018), https://www.washingtontimes.com/news/2018/jan/2/drones-fly-drugs-us-no-border-patrol-detection-tec/ [https://perma.cc/C5LS-DKRL].

[65] *Id*.

[66] *See* Zain Naboulsi, *Drone Detection: What Works and What Doesn't*, HELPNETSECURITY (May 28, 2015), https://www.helpnetsecurity.com/2015/05/28/drone-detection-what-works-and-what-doesnt/ [https://perma.cc/F5R8-VWXV] (discussing drone detections using audio, video, temperature, radar, and radio frequency).

[67] Gina Harkins, *Illicit Drone Flights Surge along U.S.-Mexico Border as Smugglers Hunt for Soft Spots*, WASH. POST (June 24, 2018), https://www.washingtonpost.com/world/national-security/illicit-drone-flights-surge-along-us-mexico-border-as-smugglers-hunt-for-soft-spots/2018/06/24/ea353d2a-70aa-11e8-bd50-b80389a4e569_story.html [https://perma.cc/TYC5-W3FA].

[68] Brian Levesque, *Agents Struggling to Intercept Drug Smuggling Drones at the Border*, AZTECH REPORTS (Nov. 1, 2018), https://aztecreports.com/agents-struggling-to-intercept-drug-smuggling-drones-at-the-border/1889/ [https://perma.cc/V83M-8YFW].

[69] *Id.*

[70] Taylor Barnett, *Eagles Will No Longer Be Enlisted as Drone Hunters*, INTERESTING ENGINEERING (Dec. 17, 2017), *https://interestingengineering.com/eagles-will-no-longer-be-enlisted-as-drone-hunters* [https://perma.cc/9FLH-46ZB].

[71] Craig Whitlock, *When Drones Fall from the Sky*, WASH. POST (June 20, 2014), https://www.washingtonpost.com/sf/investigative/2014/06/20/when-drones-fall-from-the-sky/ [https://perma.cc/8Y9D-HHF4].

[72] *Toddler's Eyeball Sliced in Half by Drone Propeller*, BBC NEWS (Nov. 26, 2015), https://www.bbc.com/news/uk-england-hereford-worcester-34936739 [https://perma.cc/EJB7-J8QB].

of this new and uncharted territory, attorneys specializing in drone issues are in high demand.[74] The FAA has experience promulgating and enforcing rules and regulations for the sky, but there have also been several private tort cases that involved damages,[75] injuries,[76] or class action suits.[77] Because of the limited case law in this area and complex government regulations, "drone attorneys" have forged a new area of legal specialization.[78] The questions these attorneys seek to answer involve "permissible operation, civil and criminal liability, misuse, and the like."[79]

While the regulatory framework is new and growing, the FAA has stepped in to create rules for drones and drone operators under Part 107 of the Code of Federal Regulations.[80] Part 107 requires a drone user to register and pay a small fee if the drone weighs more than 0.55 lb.[81] The requirement is waived for certain circumstances following application and approval by the FAA; such waiver can allow drones to operate outside of

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[73] *Drone Lawsuits & Litigation Database (2018)*, RUPPRECHT LAW P.A., https://jrupprechtlaw.com/drone-lawsuits-litigation [https://perma.cc/6NGF-9CKB].

[74] Darlene Ricker, *Navigating Drone Laws Has Become a Growing and Lucrative Legal Niche*, ABA J. (July 2017), http://www.abajournal.com/magazine/article/drone_law_attorneys [https://perma.cc/9W27-BQ5T].

[75] Jason Koebler, *The Sky's Not Your Lawn: Man Wins Lawsuit after Neighbor Shotgunned His Drone*, MOTHERBOARD (June 28, 2015), https://motherboard.vice.com/en_us/article/xywjd3/the-skys-not-your-lawn-man-wins-lawsuit-after-neighbor-shotgunned-his-drone [https://perma.cc/8FNM-LBSK].

[76] Sama Shah, *Party Guest Sues Fraternity over Falling Drone*, DAILY TROJAN (Sept. 28, 2016), http://dailytrojan.com/2016/09/28/party-guest-sues-fraternity-falling-drone/ [https://perma.cc/45TW-3DDL]; Carla Wade, *California Woman Claims She Was Hit by Drone on Las Vegas Strip during Fireworks Show*, KTNV (Aug. 24, 2018), https://www.ktnv.com/news/california-woman-suing-caesars-palace-drone-company-for-injury-after-fireworks-show [https://perma.cc/YW65-WATR].

[77] Kathryn Rattigan, *DJI Drone Manufacturer Hit with Class Action Lawsuit over Firmware Update*, DATA PRIVACY & SECURITY INSIDER (Feb. 23, 2017), https://www.dataprivacyandsecurityinsider.com/2017/02/dji-drone-manufacturer-hit-with-class-action-lawsuit-over-firmware-update/ [https://perma.cc/C5K7-YKX7].

[78] Ricker, *supra* note 74.

[79] *Id.*

[80] *Electronic Code of Federal Regulations*, GOV'T PUB. OFF., https://www.ecfr.gov/cgi-bin/text-idx?SID=dc908fb739912b0e6dcb7d7d88cfe6a7&mc=true&node=pt14.2.107&rgn=div5 [https://perma.cc/A2NE-V9CC]; *Flying Drones near Airports (Controlled Airspace) – Part 107*, FAA (Dec. 13, 2018), https://www.faa.gov/uas/commercial_operators/part_107/ [https://perma.cc/2S6S-WXRL].

[81] *If I'm Flying My UAS or Drone in My Own Yard, Do I Have to Register It?*, FAA, https://faa.custhelp.com/app/answers/detail/a_id/765/kw/General%20UAS%20or%20Drone%20Questions/related/1 [https://perma.cc/U8CD-JAAB]; *Welcome to the FAADroneZone*, FAA, https://faadronezone.faa.gov/#/ [https://perma.cc/HWM2-X9RG].

the limits of regulations.[82] Failure to register may result in regulatory and criminal penalties: civil penalties of up to $27,500, criminal penalties of up to $250,000, and imprisonment for up to three years.[83]

In addition to the registration requirements, Part 107 contains further restrictions on the operations of drones. These include limitations on flying drones near airports and stadiums,[84] as well as national parks.[85] To help drone operators navigate the complexities of the regulations, the FAA provides a mobile app called B4UFLY which shows the restricted fly areas based on the operator's current location.[86] Additionally, other operation restrictions exist, including the requirement to fly at or under 400 feet and to keep the drone within the operator's line of eye sight.[87]

Unsurprisingly, the FAA drone regulations have been challenged in courts.[88] In 2015, for example, a model aircraft hobbyist named John Taylor challenged the FAA's registration rule.[89] Taylor argued—among other things—that the rule exceeded the agency's statutory authority and was arbitrary and capricious.[90] The U.S. Court of Appeals for the D.C. Circuit upheld the regulations in *Taylor v. FAA*.[91]

The following cases demonstrate regulations on the use of drone technology represent a new and undeveloped area of the law.[92]

In 2015, the FAA sought to fine a drone-photography company, SkyPan International, $1.9 million.[93] The FAA alleged that SkyPan flew

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[82] *Part 107 Waivers*, FAA, https://www.faa.gov/uas/request_waiver/ [https://perma.cc/P4V2-X5XD].

[83] David Gewirtz, *How to Register Your Drone (It's the Law... Again)*, ZDNET (Jan. 19, 2018), https://www.zdnet.com/article/how-to-register-your-drone-its-the-law-again/ [https://perma.cc/GFN3-9B78].

[84] *Airspace Restrictions*, FAA, https://www.faa.gov/uas/where_to_fly/airspace_restrictions/ [https://perma.cc/JHQ4-CW2Y].

[85] *Unmanned Aircraft in the National Parks*, NAT'L PARK SERV., https://www.nps.gov/articles/unmanned-aircraft-in-the-national-parks.htm [https://perma.cc/7MR8-XB3M].

[86] *B4ufly Mobile App*, FAA, https://www.faa.gov/uas/where_to_fly/b4ufly/ [https://perma.cc/ZWJ6-FTFL].

[87] *Getting Started*, FAA, https://www.faa.gov/uas/getting_started/ [https://perma.cc/75GC-P78V].

[88] Taylor v. FAA, 895 F.3d 56, 56 (D.C. Cir. 2018) (upholding the FAA rule).

[89] *Id* at 60.

[90] *Id* at 58.

[91] *Id*.

[92] Huerta v. Haughwout, No. 3:16-cv-358 (JAM), 2016 WL 3919799, at *2 (D. Conn. July 18, 2016); Ricker, *supra* note 74; Chris Matyszczyk, *Drone Shooter Pleads Guilty*, CNET (Feb. 14, 2016), https://www.cnet.com/news/man-who-shot-down-drone-pleads-guilty/ [https://perma.cc/MSX5-FB45].

sixty-five unauthorized flights and lacked the proper certificate and registration for the flights.[94] The parties ultimately settled for a $200,000 civil penalty.[95]

In 2015, a video of a handgun being fired from a flying drone was released by 18-year-old Austin Haughwout.[96] The FAA subpoenaed Haughwout to submit to questioning under oath in a deposition and to produce a wide range of documents related to the video, although Haughwout was not charged with any criminal offenses, since no state law was violated.[97] Haughwout sued the FAA to resist the agency's subpoena.[98] But he was unsuccessful, and the district court ultimately decided for the FAA.[99]

In the same year, Shawn Usman lost control of a drone, which crashed on the grounds of the White House.[100] Because the drone was so small, only about two feet in diameter, the White House radar system did not detect the drone, exemplifying the difficulty in identifying and deterring errant drone use.[101] The White House initiated a security lockdown, and a Secret Service investigation followed.[102] Usman had to pay a $5,500 fine to the FAA[103] even though federal prosecutors declined to pursue criminal charges against him.[104]

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[93] Bart Jansen, *Drone-Photography Company Fined $200,000 by FAA*, USA TODAY (Jan. 17, 2017, 1:41 PM), https://www.usatoday.com/story/news/2017/01/17/faa-drone-skypan/96671342/ [https://perma.cc/JHQ4-CW2Y].

[94] *Id*.

[95] *Press Release, FAA and Skypan International, Inc., Reach Agreement on Unmanned Aircraft Enforcement Cases*, FAA (Jan. 17, 2017), https://www.faa.gov/news/press_releases/news_story.cfm?newsId=21374 [https://perma.cc/JHQ4-CW2Y].

[96] Bruce Kennedy, *5 Issues Drones Will Have to Navigate*, CBS NEWS (Aug. 20, 2015), https://www.cbsnews.com/media/5-issues-drones-will-have-to-navigate/4/ [https://perma.cc/FE29-WNRH]; Hogwit, *Flying Gun*, YOUTUBE (July 10, 2015), https://www.youtube.com/watch?v=xqHrTtvFFIs [https://perma.cc/XS49-FE6S].

[97] Kennedy, *supra* note 96.

[98] Huerta v. Haughwout, No. 3:16-cv-358 (JAM), 2016 WL 3919799, at *2 (D. Conn. July 18, 2016).

[99] *Id*. at *5.

[100] Phillip Swarts, *No Charges for Man Who Crashed Drone onto White House Lawn*, WASH. TIMES (Mar. 18, 2015), https://www.washingtontimes.com/news/2015/mar/18/no-charges-man-who-crashed-drone-white-house-lawn/ [https://perma.cc/2U8E-XF4P].

[101] *See* Michael S. Schmidt & Michael D. Shear, *A Drone, Too Small for Radar to Detect, Rattles the White House*, N.Y. TIMES (Jan. 26, 2015), https://www.nytimes.com/2015/01/27/us/white-house-drone.html [https://perma.cc/5H7C-NQZH].

[102] Swarts, *supra* note 100.

[103] Ricker, *supra* note 74.

[104] Swarts, *supra* note 100.

Federal or state law enforcement agencies can also charge civilians who attack or otherwise damage drones. As of 2016, at least a dozen shootings of drones have been reported, which could constitute a federal crime as aircraft sabotage under 18 U.S.C. § 32. However, the government has yet to pursue a federal charge for damaging drones as aircrafts.[105] At the state level, however, Russell Percenti was indicted on charges of possession of a firearm after he was tracked down and arrested by police in 2015.[106] He pled guilty to the charges and admitted that he had fired a shotgun at a drone, claiming he was trying to protect family privacy.[107] In Kentucky, a similar charge for shooting down a drone was dismissed by a district judge who stated, "[h]e had a right to shoot at this drone."[108] "In the wake of the incident, drone shootings have increased."[109] In 2019, a man was charged with third-degree criminal mischief after shooting at a drone that was being used to find a lost dog in New York.[110]

Outside the criminal realm, private suits such as tort cases,[111] and even a civil class action suit, have been filed against a drone

[105] John Goglia, *FAA Confirms Shooting a Drone Is a Federal Crime. So When Will U.S. Prosecute?*, FORBES (Apr. 13, 2016), https://www.forbes.com/sites/johngoglia/2016/04/13/faa-confirms-shooting-drone-federal-crime-so-when-will-us-prosecute/#68915aa62a25 [https://perma.cc/DBV3-SUKC].

[106] Craig McCarthy, *N.J. Man Faces Prison for Shooting Down Drone, Cops Say*, NJ.COM (Aug. 25, 2015), https://www.nj.com/news/index.ssf/2015/08/nj_man_faces_prison_for_shooting_down_drone_cops_say.html [https://perma.cc/KW82-6M28].

[107] Matyszczyk, *supra* note 92; Myles Ma, *Lower Township Man Admits to Firing Shotgun at Drone*, NJ.COM (Feb. 14, 2016), https://www.nj.com/news/index.ssf/2016/02/lower_township_man_admits_to_firing_shotgun_at_dro.html [https://perma.cc/58RU-KMTC].

[108] Eric Limer, *People Just Keep Shooting Down Their Neighbors' Drones*, POPULAR MECHANICS (May 27, 2016), https://www.popularmechanics.com/flight/drones/a21072/people-just-keep-shooting-down-drones/ [https://perma.cc/LV7W-KR3W]; Eric Limer, *Man Who Shot Down Drone Cleared of All Charges*, POPULAR MECHANICS (Oct. 27, 2015), https://www.popularmechanics.com/flight/drones/news/a17969/man-who-shot-down-drone-cleared-of-all-charges/ [https://perma.cc/3XHK-NCCT].

[109] Limer, *People Just Keep Shooting Down Their Neighbors' Drones*, *supra* note 108.

[110] *Long Island Man Arrested for Shooting Drone as It Searched for Missing Dog: Police*, NBC N.Y. (Feb. 25, 2015), https://www.nbcnewyork.com/news/local/Man-Arrested-for-Shooting-Drone-As-it-Searched-for-Missing-Dog-Police-506292601.html [https://perma.cc/FRZ9-RZB2].

[111] Wade, *supra* note 76; Molly Zilli, *USC Fraternity Settles Drone Injury Lawsuit*, FINDLAW (Apr. 30, 2018), https://blogs.findlaw.com/injured/2018/04/usc-fraternity-settles-drone-injury-lawsuit.html [https://perma.cc/5VTH-6C9L]; Lisa Harig, *Insurance Company Denies Coverage for Drone Injury at Wedding*, LEXOLOGY (Nov. 14, 2018), https://www.lexology.com/library/detail.aspx?g=500b366f-8a6f-44f8-9368-dedb80a178ef [https://perma.cc/3RXW-U8HC].

manufacturer.[112] The potential for other private law suits with varying causes of action is high. For example, while experts say that "a standard homeowner's policy or optional comprehensive insurance on the car would cover any damages" if a drone damages a house or car,[113] a lawsuit may still be necessary to resolve liability issues. Further, causes of action, such as a claim for intrusion upon seclusion[114] may provide victims a private means for enforcement of their privacy rights. Overall, while drones add a new layer of complexity to the law, often the existing set of civil laws can be applied to the new technology.

VII. CONCLUSION

Recently, drones' adoption, usage across industries, and global awareness have significantly expanded.[115] The main reasons for this spike in popularity, especially in the consumer market, are low costs and easy controls for the drones. Further, the technology of drones continues improve due to advances in sensor and stabilizing controller technology.[116]

Drones are now utilized by a broad spectrum of users from photographers to law enforcement and even drug traffickers. Legal battles have begun to shape the outer limits of drone usage, and the FAA has stepped in with regulations to guide hobbyists and businesses alike. The pace of adoption is not expected to slow, and the use of drones is expected to increase significantly.[117] Legal issues and cases are likely to increase as well, and, as with any technology, finding the right balance between the legal and technical issues will ultimately impact the future utilization of the drone technology.

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[112] Rattigan, *supra* note 77.
[113] Kennedy, *supra* note 96.
[114] Benjamin D. Mathews, *Potential Tort Liability for Use of Drone Aircraft*, 46 ST. MARY'S L.J. 573, 586–87 (2015).
[115] *See* Divya Joshi, *Exploring the Latest Drone Technology for Commercial, Industrial and Military Drone Uses*, BUS. INSIDER (July 13, 2017, 4:40 PM), https://www.businessinsider.com/drone-technology-uses-2017-7 [https://perma.cc/ZMP8-BAP8].
[116] Clément Christomanos, *Why Have Drones Suddenly Become a Big Thing? Are There Any Recent Technological Reasons Why Drones Have Started to Prevail?,* QUORA (Sept. 27, 2016), https://www.quora.com/Why-have-drones-suddenly-become-a-big-thing-Are-there-any-recent-technological-reasons-why-drones-have-started-to-prevail [https://perma.cc/VA5H-THVD].
[117] Andy Pasztor, *FAA Projects Fourfold Increase in Commercial Drones by 2022*, WALL ST. J. (Mar. 18, 2018), https://www.wsj.com/articles/faa-projects-fourfold-increase-in-commercial-drones-by-2022-1521407110 [https://perma.cc/M8PF-VFR6]; *FAA Aerospace Forecast Fiscal Years 2017-2037*, FAA, https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf [https://perma.cc/Z286-SQT8].