

Deadly Drones? Why FAA Regulations Miss the Mark on Drone Safety

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ABSTRACT

A rapidly growing commercial drone industry has prompted the introduction of numerous regulations governing American airspace. Congress has tasked the Federal Aviation Administration (FAA) with “developing plans for the use of the navigable airspace to ensure the safety of aircraft and the efficient use” of American skies. While well-intended, the FAA has departed from Congressional will by imposing an excessive regulatory regime that threatens to stifle drone technology and innovation. In fact, many FAA regulations fail to address the very problem they seek to fix, namely the safety of our airspace. The unfortunate result is that myriad scientific and pragmatic applications of cutting-edge drone technology have been stalled or thwarted entirely inside the United States, forcing innovation efforts to move abroad.

FAA regulations must be dramatically scaled back and reformed to reflect the countless benefits and comparatively minimal risks associated with drone technology. The current rules cover innocuous use cases, are too restrictive even when addressing cases where regulation makes sense, and fail to permit efficient technical approaches to reaching regulatory objectives. The nonsensical rule requiring any person over the age of thirteen to

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register her recreational “Christmas toy” drone is an excessive response to public safety concerns, especially as far more prominent threats to public safety, even guns, have no similar registration requirements. More pragmatically, the line-of-sight regulations that prevent pilots from using vision-enhancing devices such as first-person view technology needlessly restrict the commercial applications of drones, including long-distance package delivery. Finally, while the FAA and other regulatory bodies currently control the spaces in which drones can be legally flown, drone manufacturers are far better equipped to accomplish this goal themselves by incorporating geofencing technology (which directly prevents drones from flying into restricted areas like airports). In sum, American laws and regulations governing the flight of commercial drones are overly restrictive, unnecessarily stifle valuable innovation, and must be revised to ensure that the true potential of drone technology can be realized.

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I. INTRODUCTION

Imagine a world in which Amazon’s celebrated two-day delivery system was rendered obsolete by thirty-minute drone delivery.¹ Or, what if individuals in rural communities could receive essential medical supplies and blood in emergencies with just a touch of a button?² What if missing hikers in the wilderness or individuals stranded by wildfire or floods could easily and quickly be rescued without risking the lives of first responders?³ Remarkably, none of these are hypotheticals. Drones have already accomplished each of these miraculous tasks—

1. James Vincent & Chaim Gartenberg, *Here’s Amazon’s New Transforming Prime Air Delivery Drone*, THE VERGE (Jun. 5, 2019), <https://perma.cc/S9UW-4QV2>.

2. Chloe Taylor, *Drones Set To Deliver Blood and Medical Supplies to Ghana’s Hospitals*, CNBC (Dec. 13, 2018), <https://perma.cc/NB8R-ZQXT>.

3. Kashmir Hill, *Drone Team That Finds Missing People and Dead Bodies Would Like To Keep Doing That*, FORBES (Apr. 7, 2014), <https://perma.cc/F95H-55AS> (hikers); Katie Collins, *London Police Deploy Drones To Search for Missing People*, CNET (Sept. 13, 2017), <https://perma.cc/R7F9-XBV4> (other missing persons).

and more—in controlled testing environments or in real situations abroad.⁴ However, these applications have failed to become ubiquitous in the United States because the Federal Aviation Administration (FAA) has promulgated a series of regulations that have dramatically limited the otherwise unbounded potential of drone technology.⁵

This is a cautionary tale of how well-intended laws and policies aimed at enhancing safety can silently cost lives rather than protect them. The FAA began creating guidelines around usage of radio-controlled aircraft back in the 1980s, as model planes grew in popularity.⁶ Most of these guidelines were lenient, for at the time the agency's main purpose was to regulate manned passenger aircraft, not recreational planes.⁷ However, this relaxed approach changed dramatically in the 2000s, as consumer drones began inundating the skies.⁸ Many new manufacturers entered the industry, rapidly accelerating innovation and making small drones available to everyone at relatively low cost.⁹ In turn, this led to a media obsession with the gadgets, making them a staple of modern popular culture. From the Super Bowl to the Olympics, drones were seemingly everywhere.¹⁰

4. *Amazon Says It May Take Drone Testing Outside U.S.*, BBC (Dec. 9, 2014), <https://perma.cc/KS45-839F>; Jack Nicas, *Amazon Says FAA Approval To Test Delivery Drones Already Obsolete*, WALL ST. J. (Mar. 24, 2015), <https://perma.cc/85LY-ZQRF>; *UAS Test Sites*, FED. AVIATION ADMIN. (Oct. 23, 2018), <https://perma.cc/V24B-L45K>.

5. Marisa Garcia, *Risk-Averse Culture at FAA Stifles Progress on Drones, Scientists Say*, FORBES (Jun. 12, 2018), <https://perma.cc/2T8H-RJZC>; Mehboob Jeelani, *Is the FAA Limiting Drone Innovation?*, FORTUNE (Aug. 28, 2014), <https://perma.cc/UW73-SNZJ>.

6. Unmanned Aircraft Operations in the National Airspace System, 72 Fed. Reg. 6689 (Feb. 13, 2007) (to be codified at 14 C.F.R. pt. 91) (recounting history) [hereinafter *FAA Policy Statement*]; see also *A Brief History of the FAA*, U.S. DEP'T TRANSP. (Jan. 4, 2017), <https://perma.cc/FAP3-SM9Q>; Abby Speicher, *Drone Laws: The History of Drone Regulations and Laws*, DART DRONES (Nov. 9, 2016), <https://perma.cc/CWT9-447F>.

7. See generally Elizabeth L. Ray, Federal Aviation Administration, Advisory Circular: Model Aircraft Operating Standards, AC No. 91-57A (Sept. 2, 2015), <https://perma.cc/AR4H-DRTU> (noting that the earliest document the FAA published regarding model aircrafts was in 1981, which was optional) [hereinafter AC 91-57]; *FAA Policy Statement*, *supra* note 6 (clarifying that the FAA's regulations governed recreational drones in their 2007 policy statement—a relatively recent policy).

8. *FAA Policy Statement*, *supra* note 6 (finding that “[r]egulatory standards need to be developed to enable current technology for [drones] to comply with” regulations because drones are “growing dramatically”); see generally Andrew Meola, *Drone Market Shows Positive Outlook with Strong Industry Growth and Trends*, BUS. INSIDER (Jul. 13, 2017), <https://perma.cc/TM8K-6E3H>; Sallary French, *Drone Sales in the U.S. More Than Doubled in the Past Year*, MARKETWATCH (May 28, 2016), <https://perma.cc/NL6P-DERW>.

9. April Glaser, *DJI Is Running Away with the Drone Market*, VOX (Apr. 14, 2017), <https://perma.cc/BS2J-BVQD>; Divya Joshi, *Here Are the World's Largest Drone Companies and Manufacturers To Watch and Invest In*, BUS. INSIDER (Jul. 18, 2017), <https://perma.cc/Z3NB-HU33>; Colin Snow, *Seven Trends That Will Shape the Commercial Drone Industry in 2019*, FORBES (Jan. 7, 2019), <https://perma.cc/MH48-63TC>.

10. See *infra* discussion in Part III.B; Brian Barrett, *Inside the Opening Ceremony World-Record Drone Show*, WIRED (Feb. 9, 2018), <https://perma.cc/9Y4S-WPQM>.

However, the American honeymoon with drone technology was short-lived. People began to wonder about the public safety risks posed by one crashing into the White House, or God forbid, into a passenger airliner in flight.

Our changing aerial landscape, as well as the terrifying events of 9/11, placed immense pressure on various regulatory bodies to intervene in order to keep American airspace safe.¹¹ The FAA began a new regulatory campaign that has continued unabated to this day, resulting in an excessive regime that has negatively impacted the many productive uses of drones. Most prominently, FAA rules require that all drone operators register their personal information with the federal government,¹² and the FAA instituted a “line of sight” requirement that forbade any pilot from flying her drone outside of her natural field of vision.¹³

In theory, these regulations were aimed at promoting public safety. Regulators hoped the registration mandate would encourage operators to fly safely and discourage malicious drone use since each pilot would be linked to their drones in a federal database.¹⁴ Additionally, by prohibiting the flying of drones beyond the pilot’s line of sight, drone flight would be safer because operators would be able to see and maneuver their drones to avoid hazards.¹⁵

Though well intended, the FAA regulations are seriously misguided and largely ineffective. Requiring thirteen-year-old children to reveal their home address, phone number, and email when they receive a drone as a Christmas present does not deter terrorist behavior in the least.¹⁶ And the line-of-sight requirement thwarts nearly all commercial and public safety applications of the technology, pushing innovation abroad at America’s expense.¹⁷ Although there are legitimate concerns associated with reckless or nefarious drone usage, an individual who has a specific intent to crash their drone into a larger aircraft or use it in a terrorist

11. *No Drone Zone*, FED. AVIATION ADMIN. (Aug. 29, 2019), <https://perma.cc/2X4E-F4GL>; Craig Whitlock, *Near-Collisions Between Drones, Airliners Surge, New FAA Reports Show*, WASH. POST (Nov. 26, 2014), <https://perma.cc/5V7X-8DJ9>.

12. 49 U.S.C. § 44807 (2018); 14 C.F.R. § 107.13 (2019).

13. 14 C.F.R. § 107.31 (2019).

14. Press Release, DJI, Registering Your DJI Drone in the U.S.: What You Need To Know (Dec. 21, 2015), <https://perma.cc/RLK4-2HBU>; see also Registration and Marking Requirements for Small Unmanned Aircraft, 80 Fed. Reg. 78593, 78600 (Dec. 16, 2015) (“Aircraft registration and marking are essential elements in the regulatory structure that provides for safe and orderly aircraft activity . . . [because t]he registration number provides a link to information about the aircraft and the owner responsible for its operations.”).

15. Jonathan Rupprecht, *Section 107.31 Visual Line of Sight Aircraft Operation* (2019), RUPPRECHT LAW P.A. (2019), <https://perma.cc/63KL-4F5Y>; Operation of Small Unmanned Aircraft Systems Over People, 84 Fed. Reg. 3856 (Feb. 13, 2019).

16. *Register Your Drone*, FED. AVIATION ADMIN. (Jul. 11, 2019), <https://perma.cc/Q22Y-CNZ8>; see also Jason Snead & John-Michael Seibler, *How the FAA’s War on Drones Is Killing a Popular Pastime*, DAILY SIGNAL (Dec. 27, 2016), <https://perma.cc/BQ5C-VH3L> (“[T]he registry does nothing to deter or prevent bad actors from using drones to commit crimes or acts of terror.”).

17. *Amazon Says It May Take Drone Testing Outside U.S.*, *supra* note 4.

attack is unlikely to register their identity in advance with Uncle Sam or make sure their drones remain within their line of sight.¹⁸

Not only do the FAA rules fail to address practical realities surrounding threats from drones, they also needlessly chill the potential benefits of the technology. The FAA's line-of-sight rule, in particular, has destroyed the potential to realize immense commercial and public safety benefits—how can a drone pilot deliver packages or emergency supplies or rescue victims during natural disaster if she must be able to see her device with her own two eyes?¹⁹ This limitation disincentives technology giants like Amazon and Google from investing domestically²⁰ and has instead pushed innovation, testing, and investment in drones abroad, taking with them millions of jobs and billions in revenue.²¹ The FAA's regulatory scheme further limits all kinds of applications that have proven (on the international stage) to be invaluable to businesses,²² scientific research,²³ and disaster recovery.²⁴ Without a regulatory makeover, the FAA will continue to thwart drone-induced benefits and innovation that could improve, and even save, American lives.

This Article highlights the shortcomings of the FAA's regulatory scheme, and proposes to fight fire with fire by using technology to solve technology's own problems. Rather than pretending that terrorist pilots will register their drones with the federal government and keep them within eyesight, we propose the dramatic expansion of geofencing technology to directly regulate where drones can—and cannot—fly. This technology creates a virtual map of safe zones, di-

18. Steve Calandrillo, *Responsible Regulation: A Sensible Cost-Benefit, Risk Versus Risk Approach to Federal Health and Safety Regulation*, 81 B.U. L. REV. 957 (2001) (noting that people respond more to the fear of terrifying rare events than they do to common causes of death that are much more routine and therefore less frightening.).

19. Dave Marcontell & Steve Douglas, *Why the Use of Drones Still Faces Big Regulatory Hurdles*, FORBES (Sept. 10, 2018), <https://perma.cc/NN2D-5339>; Jonathan Rupprecht, *Feds Make Major Moves To Relax Restrictions on Use of Drones*, FORBES (Jan. 14, 2019), <https://perma.cc/A9KV-J74R>.

20. Jake Kanter, *Google Just Beat Amazon to Launching One of the First Drone Delivery Services*, BUS. INSIDER (Apr. 9, 2019), <https://perma.cc/KHL6-6D6F>; Jonathan Vania, *Sorry, Drone Deliveries Aren't Coming Any Time Soon*, FORTUNE (Feb. 9, 2017), <https://perma.cc/NLQ8-S2FX>.

21. See DARRYL JENKINS & BIJAN VASIGH, ASS'N FOR UNMANNED VEHICLE SYS. INT'L, *THE ECONOMIC IMPACT OF UNMANNED AIRCRAFT SYSTEMS INTEGRATION IN THE UNITED STATES* (2013); Trevir I. Nath, *How Drones Are Changing the Business World*, INVESTOPEA (Jun. 25, 2019), <https://perma.cc/5JN2-CWUW>; Benjamin Powers, *Drones Are Powering New Jobs*, VERIZON (Oct. 17, 2018), <https://perma.cc/S5W4-SVCM>.

22. Nath, *supra* note 21.

23. Renee Cho, *How Drones Are Advancing Scientific Research*, STATE OF THE PLANET (June 16, 2017), <https://perma.cc/6Q8F-SH7R>.

24. ALLISON FERGUSON, PRECISIONHAWK, *OPENING THE SKIES TO BEYOND VISUAL LINE OF SIGHT DRONE OPERATIONS* (2018); Miriam McNabb, *FAA Issues the First Ever COA for Beyond Visual Line of Sight for a Public Safety Organization*, DRONE LIFE (Mar. 19, 2019), <https://perma.cc/U4ME-VF42>.

rectly incapacitating devices that attempt to pierce restricted airspace (e.g., airports or sensitive government and military facilities).²⁵ Geofencing is a far more effective solution to the problem of airspace safety than anything that the FAA has attempted to date.

Part II of this Article briefs the reader on the history of laws governing aircraft and discusses the current regulatory landscape. Part III outlines the myriad drone-induced benefits that would be possible in various American industries, including but not limited to agriculture, construction, insurance, science, and even law enforcement. Part IV acknowledges the concerns of critics and the risks presented by innovative technology. Part V analyzes the practical realities of the FAA's regulations and ultimately suggests new regulatory reform that would far better address safety concerns without compromising individual privacy and commercial innovation.

II. BACKGROUND

A. Brief History of FAA Regulations

In 1958, Congress created and authorized the Federal Aviation Administration (FAA) "to regulate aviation safety, the efficiency of the navigable airspace, and air traffic control, among other things" for aircrafts.²⁶ For decades though, radio control model airplanes were flown by hobbyists with very few restrictions.²⁷ In fact, the earliest FAA guidelines for model aircraft were published in 1981, when the FAA issued an *optional* operating standard for model aircraft (also known as "unmanned aerial vehicles" or "UAVs").²⁸

This voluntary framework functioned well for decades until the dramatic rise in popularity of inexpensive, radio-control "drones" in the 2000s put pressure on the FAA to take a more active stance. In 2007, the FAA published a policy statement interpreting drones to fall within the statutory definition of "aircraft" and

25. Kaveh Wadell, *The Invisible Fence That Keeps Drones Away From the President*, THE ATLANTIC (Mar. 2, 2017), <https://perma.cc/489A-JUCL>; Press Release, DJI, DJI Refines Geofencing To Enhance Airport Safety, Clarify Restrictions (Oct. 24, 2018), <https://perma.cc/C5GK-TWQD>.

26. 49 U.S.C. § 40103(b)(1) ("The Administrator of the Federal Aviation Administration shall develop plans and policy for the use of the navigable airspace and assign by regulation or order the use of the airspace necessary to ensure the safety of aircraft and the efficient use of airspace." (emphasis added)); Press Release, Fed. Aviation Admin, Federal vs. Local Drone Authority (July 20, 2018), <https://perma.cc/D6WF-QK9E>.

27. R.J. Van Vuren, Federal Aviation Administration, Advisory Circular: Model Aircraft Operating Standards, AC No. 91-57 (June 9, 1981), <https://perma.cc/TTZ2-DBJE> (noting that the earliest FAA policy that applied to drones was optional—not mandatory) [hereinafter AC 91-57]; see also *FAA Policy Statement*, *supra* note 6 (finding that drones were indefinitely subject to FAA regulations once the FAA released a policy statement clarifying its jurisdiction over drones in 2007).

28. AC 91-57A, *supra* note 7; see also AC 91-57, *supra* note 27.

thus within its regulatory purview.²⁹ In that notice, the FAA delineated the difference between commercial and recreational drones.³⁰ The agency promulgated guidance that for the first time subjected commercial drone operations to mandatory FAA regulations.³¹ For example, the regulations required minimum pilot qualifications (e.g., understanding of the relevant rules and regulations and passage of a knowledge test before earning a private pilot certificate), and operations requirements (e.g., maintain low altitude and line of sight).³² This policy statement thus deviated from the “longstanding *voluntary* regulatory approach” for drones by the FAA.³³

A few years later, Congress enacted the FAA Modernization and Reform Act of 2012, which required the FAA to establish additional regulations to improve aviation safety and provide a framework for integrating new technology (like drones) into American airspace.³⁴ Notably, this Act included Section 336, which prohibited the FAA from creating any new regulations governing model aircraft.³⁵ This section, specifically, “codified the FAA’s longstanding hands-off approach to the regulation of model aircrafts.”³⁶ Accordingly, the Act defined “model aircraft” as “an unmanned aircraft that is—(1) capable of sustained flight in the atmosphere; (2) flown within visual line of sight of the person operating the aircraft; and (3) flown for hobby or recreational purposes.”³⁷ Because the scope of Section 336 was ambiguous, the FAA published an interpretation that explained that “to qualify as a model aircraft, the aircraft would need to be operated purely for recreational or hobby purposes.”³⁸ Thereafter, the FAA applied already existing manned-aircraft regulations to all model aircrafts, commercial or not.³⁹

In 2015, the FAA again expanded its purview by creating the “Part 48 Regulations,” which applied to Section 336-protected model aircrafts. Part 48 “provides registration and identification requirements” for drones, essentially requiring all drone operators to register their drones with the FAA.⁴⁰ This registration rule requires drone owners to provide to the FAA their names, physical, mailing,

29. *FAA Policy Statement*, *supra* note 6; FED. AVIATION ADMIN., UNMANNED AIRCRAFT SYSTEMS OPERATIONS IN THE U.S. NATIONAL AIRSPACE SYSTEM—INTERIM OPERATIONAL APPROVAL GUIDANCE, AFS-400 UAS POLICY 05-01 (2005).

30. *FAA Policy Statement*, *supra* note 6.

31. *Id.*

32. *Id.*

33. *Taylor v. Huerta*, 856 F.3d 1089, 1091 (D.C. Cir. 2017) (emphasis added) (citing *FAA Policy Statement*, *supra* note 6).

34. Pub. L. No. 112-95 (codified in scattered sections of 49 U.S.C.).

35. *Id.*

36. *Taylor*, 856 F.3d at 1091.

37. FAA Modernization and Reform Act § 336.

38. U.S. DEP’T. OF TRANSP., FED. AVIATION ADMIN., INTERPRETATION OF THE SPECIAL RULE FOR MODEL AIRCRAFT 5 (2014), <https://perma.cc/J9QP-ZFRQ> [hereinafter INTERPRETATION OF THE SPECIAL RULE].

39. *Id.*

40. 14 C.F.R. § 48.

and email address, and “any other information the FAA chooses to require.”⁴¹ Additionally, this rule “creates an online platform for registration, establishes a \$5 per-individual registration fee, sets compliance deadlines,” and requires all drones to display an identification number provided by the FAA.⁴² Failure to comply with these registration rules may lead to civil or criminal monetary penalties and up to three years in prison.⁴³

Clearly, the FAA implemented rules with its registration requirement, which directly violated Section 336. Consequently, these regulations were challenged in the courts by the *Taylor v. FAA* series of cases.⁴⁴ John Taylor, the suit’s plaintiff, requested that the court issue an order declaring that the FAA’s registration rule was prohibited by Section 336 of the FAA Modernization and Reform Act of 2012.⁴⁵ Specifically, Taylor argued that the Act prohibited the FAA from creating new regulations for recreational drones.⁴⁶ The United States Court of Appeals for the District of Columbia Circuit agreed with Taylor and held that the FAA lacked statutory authority to create its registration rule.⁴⁷ The court reasoned that Section 336 clearly prevents the FAA from implementing any recreational drone regulations, and Part 48 (i.e., drone registration) is obviously a rule.⁴⁸ The court thus held that Part 48 is void, noting that “[s]tatutory interpretation does not get much simpler” than this.⁴⁹ While this litigation succeeded in vacating the FAA’s registration rule, Congressional Republicans and the Trump Administration effectively overturned *Taylor* with the passage of the National Defense Authorization Act in 2018.⁵⁰ This Act, specifically, states:

Restoration of Rules for Registration and Marking of Unmanned Aircraft—The rules adopted by the Administrator of the Federal Aviation Administration in the matter of registration and marking requirements for small unmanned aircraft (FAA-2015-7396; published on December 16, 2015) that were vacated by the United States Court of Appeals for the District of Columbia Circuit in *Taylor v. Huerta* (No. 15-1495; decided on May 19, 2017) shall be restored to effect on the date of enactment of this Act.⁵¹

41. *Taylor*, 856 F.3d at 1091-92.

42. *Id.*

43. *Id.*

44. *Id.* at 1090.

45. *Id.*

46. *Taylor*, 856 F.3d at 1092.

47. *Id.* at 1090.

48. *Id.* at 1092.

49. *Id.*

50. INTERPRETATION OF THE SPECIAL RULE, *supra* note 38.

51. National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-404 § 1092(d) (2017).

As explained below, the FAA has relied upon this legislation to continue to impose onerous restrictions for both commercial and recreational drone use today.

B. *Current Regulatory Landscape Governing Drones*

Current FAA regulation distinguishes between commercial and recreational drones, resulting in separate bodies of rules that govern American airspace.

1. *Commercial Drone Regulations*

The FAA has imposed stringent requirements for commercial drones weighing less than fifty-five pounds through Part 107 of its regulations.⁵² At its heart, Part 107 provides for “line of sight” operating requirements and mandatory pilot certifications, both of which eliminate nearly all practical applications of the emerging technology.⁵³

In simple English, that means that drones cannot fly past their pilot’s visual line of view, which is usually not more than a few hundred yards.⁵⁴ Alternatively, an observer must visually observe the drone at all times with unaided sight (e.g., no binoculars) if the pilot uses “First-Person View” (FPV) or similar technology.⁵⁵ (FPV technology would otherwise allow the pilot to operate a drone miles beyond her visual line of sight by utilizing a camera in the drone’s cockpit to transmit a video image back to the operator’s position.) The FAA also prohibits commercial drones from flying at night,⁵⁶ above 400 feet,⁵⁷ faster than 100 miles per hour,⁵⁸ or over crowds of people.⁵⁹ The FAA does, however, allow commercial drones to carry an external load or transport property—but only if the load is securely attached, does not adversely affect the flight characteristics,⁶⁰ and together with the drone weighs less than fifty-five pounds.⁶¹

Additionally, the FAA requires that all commercial drone operators obtain a remote pilot certificate with a small UAS rating, or be under the direct supervision of a person with this certificate.⁶² To obtain this certificate, operators must be at least sixteen years old and either (1) pass an initial aeronautical knowledge test at an FAA-approved knowledge testing center or (2) complete a flight review

52. Small Unmanned Aircraft Systems, 14 C.F.R. §§ 107.1, 107.3 (2019).

53. *Id.* at § 107.31.

54. *Id.*

55. *Id.* at § 107.33.

56. *Id.* at § 107.29.

57. *Id.* at § 107.51.

58. *Id.*

59. *Id.* at § 107.25.

60. *Id.* at § 107.49.

61. *Id.* at § 107.3.

62. *Id.* at § 107.63.

and take a small UAS online training course if that individual already has a Part 61 pilot certificate.⁶³

Finally, the FAA may waive the above requirements if it determines that a drone operator can safely conduct operations without adhering to the requirements.⁶⁴ Notably, the FAA can waive certain, but not all, restrictions such as operating within the visual line of sight, over crowds of people, during daylight, and in certain airspace.⁶⁵ While these waivers are sometimes granted, the time and red tape involved in obtaining one makes them impractical for most immediate drone technology applications.

2. Recreational Drone Regulations

Recreational drone operators must also comply with stringent FAA regulations.⁶⁶ The landscape of recreational drone regulation has undergone significant change, as recently as May of 2019.⁶⁷ There are two notable new requirements: (1) pilot education and (2) flight restrictions into controlled airspace.

First, recreational drone operators must pass an “online aeronautical knowledge and safety test and carry proof of test passage,” akin to a driver’s license for automobiles.⁶⁸ However, the FAA has yet to develop the training module or the online test.⁶⁹ Prior to this requirement, recreational drone operators could fly their drones freely without any special education or flight training.⁷⁰

Second, recreational drone pilots are prohibited from flying into any “controlled airspace,”⁷¹ unless the operator obtains clearance through the FAA’s Low Altitude Authorization and Notification Capability (“LANNC”).⁷² However,

63. *Id.* at § 107.61.

64. *Id.* at § 107.200.

65. *Id.* at § 107.205.

66. 49 U.S.C. § 44809 (2019).

67. *FAA Highlights Changes for Recreational Drones*, FED. AVIATION ADMIN. (May 16, 2019), <https://perma.cc/2NT3-QG2X>.

68. *Recreational Flyers & Modeler Community-Based Organizations*, FED. AVIATION ADMIN. (Aug. 13, 2019), <https://perma.cc/53NR-SQ56>.

69. Alan Boyle, *Temporarily Grounded? Recreational Drone Operators Face New FAA Requirements*, GEEKWIRE (May 17, 2019), <https://perma.cc/78W2-9NQR>.

70. *FAA Highlights Changes for Recreational Drones*, *supra* note 67 (noting that the FAA Reauthorization Act of 2018 adds a new provision that requires recreational flyers to pass an aeronautical knowledge and safety test, which is a new requirement).

71. *Id.* Controlled airspace consists of airspace where manned aircraft fly, regions surrounding airports, among other things. *Airspace*, FED. AVIATION ADMIN. (Aug. 24, 2016), <https://perma.cc/FY9M-7DDT>.

72. *FAA Highlights Changes for Recreational Drones*, *supra* note 67.

LAANC's online system is not yet set up.⁷³ As a result, recreational drone operators are limited to fixed flight sites, which are specified in a Microsoft Excel sheet on the FAA's website.⁷⁴ Prior to this prohibition, drone operators could notify airport or air traffic control authorities if they intended to fly their drone within five miles of an airport or other controlled airspace.⁷⁵ (As a practical note, many of America's densely populated coastal cities and suburbs lie within close proximity to an airport or other controlled airspace.⁷⁶)

Aside from these recent changes, recreational drone operators must still comply with all other prior FAA restrictions, including drone registration and the visual line-of-sight rule, among other operational restrictions.⁷⁷

3. Registration

The FAA requires all recreational drone operators who are at least thirteen years old to register their drones with the federal government.⁷⁸ To register, an applicant must provide their name, physical address, e-mail address, and the drone's make and model.⁷⁹ After submission, the FAA issues a "Certificate of Aircraft Registration," which includes an FAA-issued registration number.⁸⁰ Effective February 25, 2019, the FAA requires drone operators to prominently "display the FAA-issued registration number on an outside surface of the aircraft."⁸¹ The FAA's micromanagement goes so far as to specify the means of display, insisting that the operator must mark their drone with "an engraving, permanent label, or

73. *Id.* LAANC will automate recreational airspace authorization to fly in controlled airspace. LAANC will provide access to controlled airspace near airports through near real-time processing of airspace authorizations below approved altitudes in controlled airspace. *Id.*

74. *FAA Highlights Changes for Recreational Drones*, *supra* note 67.

75. *Register Your Drone*, *supra* note 16; *FAA Highlights Changes for Recreational Drones*, *supra* note 67.

76. Mark Pearson, *How Far Are People on Average from Their Nearest Decent-Sized Airport?*, MARK PEARSON BLOG (2012), <https://perma.cc/NRP8-KEBL>.

77. *FAA Highlights Changes for Recreational Drones*, *supra* note 67 ("In addition to being able to fly without FAA authorization below 400 feet in uncontrolled airspace, recreational users must still register their drones, fly within visual line-of-sight, avoid other aircraft at all times, and be responsible for complying with all FAA airspace restrictions and prohibitions.")

78. 14 C.F.R. § 48.25(b) (2019).

79. *Register Your Drone*, *supra* note 16; *FAA Highlights Changes for Recreational Drones*, *supra* note 67.

80. 14 C.F.R. §§ 48.25(a), 48.100(d) (2019). The certificate expires three years from the date it had been issued unless renewed by the registrant. The rule also requires that the holder of a Certification of Aircraft Registration ensure that the information provided in the application remains accurate by updating the information within fourteen calendar days following a change in the information provided. *Id.*

81. *FAA Makes Major Drone ID Marking Change*, FED. AVIATION ADMIN. (Feb. 13, 2019), <https://perma.cc/BKP3-MA34> [hereinafter *ID Marking Change*].

a permanent marker.”⁸² This change, the FAA believes, “will enhance safety and security by allowing a person to view the unique identifier directly without handling the drone” because “law enforcement officials and the FAA’s interagency security partners have expressed concerns about the risk that a concealed explosive device might pose to first responders upon opening a compartment to find a drone’s registration number.”⁸³ Unfortunately, the FAA ignores that a terrorist actor will not register themselves with the agency in the first place.

4. *Flight Requirements: Line of Sight, Low Altitude, No Airports, No People*

As mentioned above, drone operators must be able to see their drones directly when operating.⁸⁴ Drones must be flown within the visual line of sight of the pilot or within the visual line of sight of an observer who is co-located and in direct communication with the pilot.⁸⁵ Furthermore, the FAA imposes additional operational restrictions, requires drones to be flown below 400 feet,⁸⁶ and prohibits drone flights over crowds of people, public events, or stadiums,⁸⁷ or near emergency responses to accidents, fires, or hurricanes.⁸⁸

III. CURRENT DRONE TECHNOLOGY APPLICATIONS AND BENEFITS

Drone technology has the potential to reshape the lives of Americans if the regulatory environment permits it to do so. Because of their unparalleled versatility, drones offer “a market opportunity that is too large to ignore” for manufacturers and investors.⁸⁹ In fact, the benefits from this market opportunity could be staggering, as Goldman Sachs forecasts drones will make up a \$100-billion market by 2020.⁹⁰ Drone usage, similar to the internet and GPS before it, has extended

82. *New Requirements for Registering and Marking Small Unmanned Aircraft*, FED. AVIATION ADMIN. (Dec. 22, 2015), <https://perma.cc/SQH3-JEBY>; *How To Label Your Drone*, FED. AVIATION ADMIN., <https://perma.cc/UJ4U-JMW8> (archived Oct. 11, 2019).

83. *ID Marking Change*, *supra* note 81.

84. 14 C.F.R. § 107.31 (2019).

85. *Id.* at § 107.33.

86. *Id.* at § 107.51.

87. *Id.* at § 107.39.

88. *Id.* at § 107.45; *see generally*, *Recreational Flyers & Modeler Community-Based Organizations*, FED. AVIATION ADMIN. (Aug. 13, 2019), <https://perma.cc/Q9GE-MD9S>; *Airspace Restrictions*, FED. AVIATION ADMIN. (Aug. 7, 2019), <https://perma.cc/N8CJ-5UHF>.

89. *Drones: Reporting for Work*, GOLDMAN SACHS (2019), <https://perma.cc/LFT8-JH6V>; *see generally* Joshi, *supra* note 9.

90. *Drones: Reporting for Work*, *supra* note 89. Of this \$100 billion, \$13 billion will come from commercial businesses, such as State Farm Insurance Company and CNN. Even the FAA estimates that approximately 450,000 drones will be commercially deployed by 2022. *Id.*; Andy Pasztor, *FAA Projects Fourfold Increase in Commercial Drones by 2022*, WALL ST. J. (Mar. 18, 2015), <https://perma.cc/S4UT-U74M>.

beyond its original military purposes into (1) commercial, (2) public safety, (3) scientific, (4) conservation, (5) law enforcement, and (6) recreational applications.⁹¹

A. Commercial Drone Applications

Even though drones are a relatively new technology, commercial drone adoption has skyrocketed in recent years. American society has undergone a transformation from virtually zero commercial drones in use a decade ago to approximately 2,000,000 in operation today.⁹² This upward trend in drone use is projected to create 100,000 new jobs by 2025.⁹³ Additionally, drone-integrated industries will optimize industrial resource allocation (e.g., drones can identify construction defects early, track progress, and integrate with other technologies such as artificial intelligence to generate necessary data) and lower expenses (e.g., drones can complete inspection-related tasks within minutes without intensive labor or equipment), which then fuels commerce and innovation.⁹⁴ Recognizing these immense benefits, more and more industries—such as (1) journalism, (2) agriculture, (3) construction, (4) insurance, and (5) photography—are attempting to integrate drones into their regular operations, but are forced to do so against the backdrop of increasing FAA regulation.

1. Journalism

Drone technology has the potential to revolutionize journalism as we know it by democratizing aerial investigation and imagery, as the technology becomes significantly less expensive and more ubiquitous.⁹⁵

Drones are democratizing aerial imagery for three reasons. First, drones can reach otherwise inaccessible areas quickly, which provides opportunities for unrivaled imagery from different angles and a safer option for photo-journalists to

91. *Drones: Reporting for Work*, *supra* note 89.

92. 33 *Eye-Opening Drone Stats—Key Trends for 2019*, PHILLY BY AIR (Mar. 12, 2019), <https://perma.cc/A73S-CAMR>.

93. *Drones To Create Jobs and Billions in Economic Impact*, NAT'L ELECTRICAL CONTRACTORS ASS'N (Nov. 8, 2017), <https://perma.cc/DCQ6-H8H6>; *Drones: Reporting for Work*, *supra* note 89.

94. Andrew Meola, *Drones Could Save Us All More Than \$125 Billion*, BUS. INSIDER (May 11, 2016), <https://perma.cc/49BV-VM77>; Brian Wynne & Gary Shapiro, *The Biggest Threat to Drone Innovation Is a Group You've Never Heard Of*, TECHCRUNCH (Oct. 25, 2018), <https://perma.cc/9S85-UV3Q>; Divya Joshi, *Exploring the Latest Drone Technology for Commercial, Industrial and Military Drone Uses*, BUS. INSIDER (Jul. 13, 2017), <https://perma.cc/DHP4-P3AR>; JENKINS & VASIGH, *supra* note 21; *Drone Services Reduce Costs, Increase Efficiency on Construction Sites*, DJI OFFICIAL, <https://perma.cc/SFY9-8D92> (archived Oct. 11, 2019); Michael Cohen, *How Drones Improve Safety and Efficiency Across Industries*, INDUS. SKYWORKS (Mar. 5, 2018), <https://perma.cc/WF33-FZD3>.

95. *Here's How Drones Are Transforming News Media*, BUS. INSIDER (Jan. 3, 2017), <https://perma.cc/R49K-WEDZ>.

document dangerous areas.⁹⁶ Second, drone journalism is substantially cheaper than alternatives such as helicopter journalism.⁹⁷ Finally, technological advances such as 4K camera resolution and automated navigation technology have dramatically increased drone efficiency and production value.⁹⁸ For these reasons, drone journalism is becoming mainstream, and is now taught at major universities and by large media companies such as Syracuse University, University of Oregon, The New York Times, CNN, and the National Press Photographers Association.⁹⁹

Most importantly, drone journalism has vastly improved documentary storytelling by allowing unparalleled use of third-person imagery and videos.¹⁰⁰ As a result, many media companies have integrated drones directly into their regular operations. In 2018, The New York Times covered the deadliest and most destructive wildfire season on record in California, where 9000 fires burned more than a million acres, destroying almost 11,000 structures and killing at least 46 people.¹⁰¹ Josh Haner, a staff photographer and senior editor for photo technology at The New York Times, captured imagery and reported for days on the devastating fires using a drone.¹⁰² Haner navigated the drone “over the jagged landscape, close enough to make out details—partially burned palm trees, and even a lone fire truck.”¹⁰³ Haner’s drone-produced images and videos were “high enough for viewers to get a sense of the massive scale of the disaster,” which dramatically improved his ability to story tell and document California’s worst-ever forest fire.¹⁰⁴ Conversely, using a helicopter as an alternative to capture the same images and videos would have been a logistical and financial nightmare—they are far more expensive, dangerous, and difficult to navigate in tight areas than versatile drones.¹⁰⁵

Additionally, drones gave The New York Times an enterprise tool “to give readers a sky-view perspective on some of the year’s most visual stories.”¹⁰⁶ For

96. Sarah Whittaker, *Drones in Journalism*, DRONE BELOW (Jan. 4, 2018), <https://perma.cc/6A5B-YKCL>.

97. *Id.*

98. *See id.*

99. Vicki Krueger, *Announcing Poynter’s 2017 Drone Journalism School*, POYNTER (Jan. 30, 2017), <https://perma.cc/ZB26-S3AX>.

100. Tom Burton, *Storytelling with Drones; Tips from Journalists*, NPPA (Aug. 16, 2016), <https://perma.cc/29D6-CNBH>.

101. Chuck DeVore, *California’s Devastating Fires Are Man-Caused—But Not in the Way They Tell Us*, FORBES (Jun. 30, 2018), <https://perma.cc/83GC-6A25>; Travis Fox, *Drone Journalism’s Battle for Airspace*, COLUM. JOURNALISM REV. (Oct. 9, 2018), <https://perma.cc/5GGZ-KW8H>; Lauren Tierney, *2017 Was California’s Largest and Most Destructive Fire Season in a Decade*, WASH. POST (Jan. 4, 2018), <https://perma.cc/8796-WACU>.

102. Fox, *supra* note 101.

103. *Id.*

104. *Id.*

105. *Id.*

106. Josh Haner & Larry Buchanan, *5 Times Drones Told the Story*, N.Y. TIMES (Dec. 14, 2016), <https://perma.cc/KQ3V-5EBF>.

example, The Times used drones to visually illustrate how climate change and human activities have forced people out of the cities and suburbs, and into deserts in China.¹⁰⁷ Drones were used to highlight the enormous scale and rate in which people are creating cities and farms in the desert, which can only be captured properly through an aerial view.¹⁰⁸ In addition The Times used drones to show its readers the new Panama Canal without putting any of its investigators and journalists in harm's way.¹⁰⁹ It even utilized drones to show readers the vast impact of the Syrian Civil War on Aleppo, which was featured prominently on the front page of the newspaper.¹¹⁰ The Times' repeated use of drones to report on these global stories of incredible consequence are just a few examples of the increasing trend towards drone journalism, and the tremendous impact it can have on our society's understanding of crucial, complex issues.

Likewise, CNN has integrated drones into its operations, launching CNN Aerial Imagery and Reporting ("CNN AIR") in 2016.¹¹¹ CNN AIR uses drones to "fully integrate aerial imagery and reporting across all CNN networks and platforms."¹¹² By integrating drone technology, CNN provides its viewers with improved storytelling through enhanced production and dynamic video angles.¹¹³ For example, CNN AIR used drones to demonstrate the scale of Louisiana's devastating floods in 2016 and the 2015 water crisis in Flint, Michigan; the 2018 civil rights march in Selma, Alabama; the tenth anniversary of Hurricane Katrina; the Republican and Democratic presidential nominating conventions; and the CNN presidential primary.¹¹⁴

While drones have the potential to provide immediate benefits to the journalism industry, regulatory hurdles hinder widespread adoption. For example, before The New York Times' Josh Haner could report on California's devastating wildfires, he had to first verify that the FAA did not close the airspace or impose other flight restrictions, coordinate with local law enforcement to find a safe take-off and landing location, use a second drone pilot to watch for sudden changes in the sky, and fly his drone within his line of sight, among other tight restrictions.¹¹⁵ Moreover, the FAA selected CNN as one of three partners for its Pathfinder program, allowing CNN to use drones for newsgathering in exchange for receiving

107. Josh Haner et al., *Living in China's Expanding Deserts*, N.Y. TIMES (Oct. 24, 2016), <https://perma.cc/E642-5B7C>.

108. *Id.*

109. Haner & Buchanan, *supra* note 106.

110. *Id.*; Michael Kimmelman, *Berlin, 1945; Grozny, 2000; Aleppo, 2016*, N.Y. TIMES (Oct. 14, 2016), <https://perma.cc/M2TH-7C8U>.

111. Press Release, CNN, CNN Launches CNN Air (Aug. 18, 2016), <https://perma.cc/68NF-76EG>.

112. *Id.*

113. *Id.*

114. *Id.*

115. Fox, *supra* note 101.

CNN's data and research in return.¹¹⁶ CNN and the Georgia Tech Research Institute entered into a direct research partnership with the FAA to help the agency formulate more flexible and comprehensive regulations to safely integrate drones into the national air space.¹¹⁷ Without partnerships like this, obtaining a permit to fly drones for newsgathering takes two or three months, which effectively eliminates drone usage for breaking news coverage.¹¹⁸ While the FAA is taking small strides in the right direction by granting limited waivers, the underlying drone regulations need significant reform to unleash the immense benefits and needs for this technology in the field of journalism.

2. Precision Agriculture

In addition to enhancing journalism, drone technology has enormous potential to improve agricultural production and contribute to the fight against food insecurity. At any given moment, more than 815 million people across the globe are chronically hungry.¹¹⁹ Food insecurity will only become a larger problem as the world population increases by approximately 20% by 2050, according to the Food and Agriculture Organization of the United Nations.¹²⁰ With declining resources (e.g., land and water) and increasing extreme weather events, growing food has become far more challenging.¹²¹ Fortunately, drones and advancing technologies can help by maximizing crop efficiency and yields through techniques often referred to as "precision agriculture" or "smart farming."¹²² In fact, PwC estimates that drone-powered agricultural solutions will become a large factor in our fight against food insecurity, potentially comprising a \$32 billion market.¹²³

116. CNN Launches CNN Air, *supra* note 111. The FAA's Pathfinder program was created to partner up with companies that want to use drones. Specifically, CNN explored how drones might be used safely for newsgathering in populated areas (i.e., over people). CNN's information and data were shared with the FAA as part of the Pathfinder program to find ways to create flexible drone regulations. *Completed Programs and Partnerships*, FED. AVIATION ADMIN. (OCT. 27, 2018), <https://perma.cc/XYC6-ZBPY>.

117. CNN Launches CNN Air, *supra* note 111.

118. Laura Testino, *CNN and Georgia Tech Are Exploring Ways To Use Drones in Journalism*, ATLANTA MAG. (Jun. 24, 2014), <https://perma.cc/K76Q-DZCP>.

119. GERARD SYLVESTER ET AL., *E-AGRICULTURE IN ACTION: DRONES FOR AGRICULTURE* (2018), <https://perma.cc/P89G-RXL8>; Michal Mazur, *Six Ways Drones Are Revolutionizing Agriculture*, MIT TECH. REV. (Jul. 20, 2016), <https://perma.cc/V4C6-EUHP>.

120. HIGH LEVEL EXPERT FORUM—HOW TO FEED THE WORLD IN 2050, FOOD AND AGRIC. ORG. OF THE UNITED NATIONS, *GLOBAL AGRICULTURE TOWARDS 2050*, (2009), <https://perma.cc/53AM-DRFT>; *see generally* SYLVESTER ET AL., *supra* note 119.

121. Mazur, *supra* note 119.

122. SYLVESTER ET AL., *supra* note 119.

123. MICHAL MAZUR & ADAM WISNIEWSKI, PwC, *CLARITY FROM ABOVE: PwC GLOBAL REPORT ON THE COMMERCIAL APPLICATIONS OF DRONE TECHNOLOGY* (2017), <https://perma.cc/G6TS-4RUQ>.

To maximize production, crops must be fertilized, watered, and harvested at precisely the right time and place.¹²⁴ For example, harvesting crops prematurely, neglecting defects early on, overwatering, or using too much pesticide negatively impact yields.¹²⁵ Fortunately, drones can address these concerns by allowing “planning and strategy based on real-time data gathering and processing,” providing farmers with critical information to assist them in maximizing crop production.¹²⁶

First, drones have the ability to provide farmers with information on precisely when to irrigate or apply fertilizers to crops.¹²⁷ To obtain this information, farmers can easily deploy their drones to take pictures and videos of their crops in various stages of growth.¹²⁸ Then, farmers can use these images to assess specific regions of the field to detect visual defects or deficiencies early on, such as diseases or dehydration.¹²⁹ Once an issue has been identified, farmers can re-deploy drones to apply water or fertilizers to specific crops, which importantly only treats affected areas.¹³⁰ Prior to the availability of drone technology, farmers had to order advanced satellite imagery or fly small planes over their fields to obtain similar data and imagery—an extremely time-consuming and costly method by comparison.¹³¹

124. *Id.*; SYLVESTER ET AL., *supra* note 119; see PAUL C. HAY, UNIV. OF NEBRASKA-LINCOLN EXTENSION, TOP SEVEN FACTORS IN CROP PRODUCTION, <https://perma.cc/FWK4-HV44> (archived Jan. 5, 2020); Gary Zoubek & Chuck Burr, *Managing Soybean Harvest Timing, Moisture To Improve Yield*, U. NEB.-LINCOLN CROPWATCH, <https://perma.cc/HV3S-SD2V> (archived Feb. 28, 2020).

125. See generally Hay, *supra* note 124; Mazur, *supra* note 119.

126. Mazur, *supra* note 119; MAZUR & WISNIEWSKI, *supra* note 123.

127. Mazur, *supra* note 119; MAZUR & WISNIEWSKI, *supra* note 123; SYLVESTER ET AL., *supra* note 119.

128. SYLVESTER ET AL., *supra* note 119. In layman’s terms, drones create 3D maps and advanced images of fields, which give farmers the necessary information and tools to plan and manage their crops—leading to improved crop productivity. Drones are deployed for cyclical flights over crops to collect data, indicate the precise timing for harvest, and provide accurate weather forecasts. Furthermore, drone-collected data is used to assess soil conditions “as well as moisture and water flow precisely.” *Id.* Additionally, the collected data and images are combined with other data sources to create “Normalized Difference Vegetation Index (NDVI) maps, which can differentiate soil from grass or forest, detect plants under stress, and differentiate between crops and crop stages.” *Id.* Interestingly, drone technology has improved and refined “NDVI mapping capabilities to a completely new level of accuracy, making it possible to monitor the condition of not only plants, but also specific parts of plants.” *Id.* This is extremely important because NDVI data and crop yields are strongly correlated—NDVI data provides appropriate information to track crop growth at key stages, which allows farmers to specifically identify defects (e.g., pests, diseases, deficiencies) and cure them in specific areas in order to maximize crop yields. Drones can cure diseases, for example, by flying towards the infected crop, identifying the infected area, and applying pesticides or other chemicals precisely in the infected area. *Id.*

129. SYLVESTER ET AL., *supra* note 119.

130. *Id.*

131. *Id.*

Drone-powered solutions can also help farmers detect diseases in their crops before they spread, thus mitigating damage and minimizing unnecessary expenses. For example, Agribotix, an agricultural intelligence company providing drone-enabled technologies, provided data to a farmer that allowed her to successfully eradicate bur cucumber infestation from her soybean crops.¹³² She was able to detect the infestation near the perimeter of her field and treat the issue quickly before it spread.¹³³ With this drone-powered solution, the farmer prevented further crop losses and in turn dramatically increased yields and revenues.¹³⁴

Maximizing drones' impact in our fight against global food insecurity requires widespread adoption though in the United States, and the FAA's regulations to date have limited such usage. Fortunately, the FAA is now beginning to recognize the problem and allow growing investment in the technology by farmers focused on precision agriculture to increase yields.¹³⁵

3. Construction

Drones also offer the promise that they will make an enormous impact in the construction industry. Drones can provide aerial images of construction projects to workers in real time, which is especially useful when it comes to inspecting project sites in development.¹³⁶ While simple, drones used in this capacity have resulted in immediate benefits such as reduced operational costs and increased worker safety.¹³⁷

Drones lower operational costs by providing operators with a bird's-eye view of construction sites, allowing them to monitor site progress, detect early structural defects, and identify potential hazards and quality concerns.¹³⁸ Drones also provide images from diverse angles (e.g., through obstacles or difficult-to-reach places within a construction site) in a cost-effective and efficient manner.¹³⁹ For instance, Uplift Data Partners, a drone service provider, saved a construction

132. *Agriculture Drones*, AGRITECHTOMORROW (Jun. 4, 2019), <https://perma.cc/J96T-9T68>; see generally Luke Geiver, *Survey Shows Drone Adoption Rate by Farmers*, UAS MAG. (Jul. 31, 2018), <https://perma.cc/Z2XF-88AP>.

133. Geiver, *supra* note 132; *Agriculture Drones*, *supra* note 132.

134. Geiver, *supra* note 132; *Agriculture Drones*, *supra* note 132. The early detection and optimization of inputs prevented 13% crop losses on her 110 total acres and saved a total of \$7222 (i.e., crop loss avoidance of \$5297 and savings from precise herbicide application of \$1925). CASSIDY RANKINE, SKYCLAIM (2017) (citing Agribotix statistic on slide 24).

135. SYLVESTER ET AL., *supra* note 119.

136. *The Rise of Drones in Construction*, DRONEDEPLOY (Jun. 6, 2018), <https://perma.cc/46GA-8G6V>.

137. Ibrahim Mosly, *Applications and Issues of Unmanned Aerial Systems in the Construction Industry*, 6 INT'L J. CONSTRUCTION ENGINEERING & MGMT. 235 (2017).

138. *Id.*; *The Rise of Drones in Construction*, *supra* note 136; *2018 Commercial Drone Industry Trends*, DRONEDEPLOY (May 29, 2018), <https://perma.cc/3QD9-YLPV>.

139. *2018 Commercial Drone Industry Trends*, *supra* note 138.

company \$300,000 “by finding a misalignment in the piping and pouring of a building’s foundation” through the drone’s aerial photos for only \$350.¹⁴⁰ Alternatively, this discovery would only have been made possible by using a helicopter, which would cost at least \$20,000.¹⁴¹ Because drones democratize the availability of images and immediately provide critical information to their operator, they have proven to be an invaluable tool for the construction industry.

In addition to economic efficiencies, drones also improve human safety within construction sites. Significantly, according to PwC, drones have the potential to decrease life-threatening accidents by 91% in construction-related projects.¹⁴² As detailed above, operators can use these small flying devices to remotely inspect construction sites for hazardous conditions or unstable structures without placing workers directly at risk.¹⁴³ By removing human inspections of construction or accident sites, drones have already significantly reduced worker exposure to structural collapses and accompanying injuries.¹⁴⁴ For example, Ibrahim Mosly documented how drones allowed “inspectors to safely view still images and video of the damaged areas [of buildings] and perform an accurate assessment” in cases of structural fires on rooftops.¹⁴⁵ In lieu of people, drones can now inspect “awkward or difficult-to-reach locations such as tall structures, under bridges, and along busy highways,” saving countless human lives.¹⁴⁶

Additionally, state and federal infrastructure regulations require structural inspections to ensure that buildings comply with applicable safety standards.¹⁴⁷ Instead of requiring workers to climb up 200 feet to inspect a wind turbine’s blades, for example, construction companies can deploy a drone to inspect that structure.¹⁴⁸ Using drones instead of manual inspections provides construction companies with a cost-effective method to accomplish the same task but more importantly increases human safety on construction sites—an industry well-known for causing thousands of physical disabilities and human casualties per year.¹⁴⁹

140. Jackie Bender, *This Startup’s Drones Are Saving Construction Companies Truckloads of Money*, CRAIN’S CHICAGO BUS. (Jan. 3, 2019), <https://perma.cc/SX6K-S4FU>.

141. *Id.*

142. Shea O’Donnell, *The Role of Drones in Infrastructure*, CONSORTIQ (May 2, 2017), <https://perma.cc/7B66-PFCL>.

143. Noel Borck, *Using Drones To Monitor Construction Safety*, LABORERS’ HEALTH & SAFETY FUND OF NORTH AM. (Sept. 2018), <https://perma.cc/DY4Z-A64X>.

144. Mosly, *supra* note 137.

145. *Id.*

146. April Dorsey, *Using Drones To Monitor Construction Safety*, LABORERS’ HEALTH & SAFETY FUND OF NORTH AM. (Aug. 2018), <https://perma.cc/B4DJ-P4YB>.

147. *See generally*, National Bridge Inspections Standards Regulations, 69 Fed. Reg. 74,419, 74,428 (Dec. 14, 2004) (“The FHWA believes that the inspection frequency should not exceed 24 months.”).

148. *Id.*

149. *Id.*; *Death on the Job: The Toll of Neglect, 2017*, AFL-CIO (Apr. 26, 2017), <https://perma.cc/E4J8-954W>.

Critically though, construction companies must still obtain a waiver from the FAA to fly drones beyond the pilot's line of sight to accomplish the above-described tasks, despite the obvious and immense benefits.¹⁵⁰ This red tape unnecessarily hinders broad adoption of drone technology for construction, and needs to be eliminated promptly so that the industry can maximize its potential to save lives and resources.¹⁵¹

4. Insurance

Insurance companies have already reaped enormous benefits by investing early in commercial drone technology but have yet to unlock the full potential of drones—particularly due to strict FAA drone regulations, like the visual line-of-sight rule.¹⁵² Prior to incorporating drones into their business models, insurance companies such as AIG, State Farm, and USAA must navigate the tedious and lengthy process of securing FAA permits.¹⁵³ Drones, nonetheless, have begun to collect aerial data, respond to catastrophes, and resolve insurance claims, which carries the promise of improving risk management and efficiently streamlining the entire insurance process.¹⁵⁴

It is not difficult to see that drones have great capacity to allow insurers to assess risk and process claims faster.¹⁵⁵ After an accident, drones can quickly, economically and safely inspect and obtain high-quality visuals of the damaged area or specific property.¹⁵⁶ The data and imagery collected can then be utilized by insurance companies to provide accurate and efficient claim adjustments.¹⁵⁷ For example, Country Financial reports that it can assess three times as many acres of farmland via drone as a human adjuster on foot while efficiently accounting for all of a customer's crop damage.¹⁵⁸ Similarly, by using drones Allstate has significantly reduced the time it takes to issue a home repair estimate from 11 to 4.5

150. *Part 107 Waivers*, FED. AVIATION ADMIN. (Aug. 1, 2019), <https://perma.cc/4DM3-VV97>.

151. Hallie Busta, *Drone Law: How New Rules and Evolving Tech Are Changing the Path of UAVs in Construction*, CONSTRUCTION DIVE (Mar. 27, 2017), <https://perma.cc/4GY8-KDLN>.

152. Akash Tayal & Nikhilesh Ramani, *Insurance Industry Drone Use Is Flying Higher and Farther*, DELOITTE (2019), <https://perma.cc/J3DP-W5ME>.

153. See Leslie Scism & Jack Nicas, *Insurers Get Approval To Use Drones*, WALL ST. J. (April 8, 2015), <https://perma.cc/23JP-9QUV>.

154. Tayal & Ramani, *supra* note 152; *Drones in Insurance*, DJI OFFICIAL, <https://perma.cc/YAZ2-Y983> (archived Nov. 7, 2019).

155. Tayal & Ramani, *supra* note 152; Marianne Bonner, *How Drones Will Change the Insurance Industry*, BALANCE SMALL BUS. (June 12, 2018), <https://perma.cc/2YBM-5EK2>.

156. Tayal & Ramani, *supra* note 152.

157. *Id.*; Gabriella Messina, *How Are UAVs Changing the Insurance Industry?*, POMS & ASSOCIATES, <https://perma.cc/Q93A-E75Y> (archived Nov. 7, 2019).

158. *Taking Crop Adjusting to New Heights*, COUNTRY FIN. (Aug. 21, 2017), <https://perma.cc/B75R-ZQ63>.

days.¹⁵⁹ Of course, drones also minimize adjusters' exposure to accidents and hazardous conditions, which not only increases their safety, but also inspection efficiency by up to 85%.¹⁶⁰

These operational efficiencies directly translate into economic benefits. Drones mitigate costs by eliminating expensive equipment (e.g., helicopters), and reducing the need to have trained specialists on site, who often have to make multiple site visits.¹⁶¹ Drones can capture real-time and high-quality footage of an accident site, allowing specialists to view live videos remotely or re-analyze videos and pictures without putting them in harm's way.¹⁶²

These human and economic benefits are especially important in response to natural disasters.¹⁶³ After Hurricane Florence hit North Carolina in 2018, drones were employed to collect data, which sped up the rebuilding process.¹⁶⁴ PrecisionHawk, a drone and data company, utilized drones to collect imagery of the damaged homes and property, which provided insurance customers with information necessary to settle insurance claims without deploying human inspectors.¹⁶⁵ Michael Chasen, CEO of PrecisionHawk, stated quite simply, drones have the potential to "transform the claims cycle, making it faster and safer for adjusters to observe, analyze, and assess the damage associated with incidents ranging from accidents to natural disasters."¹⁶⁶ Further, after a natural disaster hits, drones can help automate the entire process so that affected families do not have to endure additional stress over insurance claims, allowing people to resume their normal lives more quickly.

Hoping to capitalize on drones' truly disruptive potential in the field, major insurers including Allstate and Liberty Mutual have invested in the technology and incorporated them into their regular operations.¹⁶⁷ Drone usage has also evolved, as these major players are using drones to maximize efficiencies in both phases of their operations—not just post-loss as described above, but also pre-loss (i.e., before damages occur).

159. Kristin Lausten, *Use of Drones for Insurance Claims Adjusting*, LAUSTEN & CO. (Sept. 30, 2017), <https://perma.cc/DV93-75G7>; see also Barbara Marquand, *Meet Your New Insurance Claims Inspector: A Drone*, USA TODAY (Jun. 8, 2017), <https://perma.cc/V6FX-8WRK>; Jonathan Vanian, *Allstate Just Used Drones To Inspect Homes in Texas*, FORTUNE (Sept. 2, 2016), <https://perma.cc/8LPG-J2J3>.

160. Tayal & Ramani, *supra* note 152; Nicholas Newman, *How Drones Are Aiding the Energy Sector*, ENIDAY, <https://perma.cc/T5G7-Q7XE> (archived Nov. 7, 2019).

161. Tayal & Ramani, *supra* note 152; Newman, *supra* note 160.

162. Tayal & Ramani, *supra* note 152; Newman, *supra* note 160.

163. Jennifer Kite-Powell, *These Drones and Humans Will Work Together In Hurricane Florence Recovery Efforts*, FORBES (Sept. 16, 2018), <https://perma.cc/F2RE-2EX9>.

164. *Id.*

165. *Id.*

166. *Id.*

167. *Insurance Companies that Use Drones*, GRIND DRONE (May 6, 2018), <https://perma.cc/3TEA-7RUH>; see also Marianne Bonner, *How Drones Will Change the Insurance Industry*, BALANCE SMALL BUS. (Jun. 12, 2018), <https://perma.cc/2YBM-5EK2>.

During pre-loss, an adjuster or risk engineer can deploy a drone to quickly and safely assess the initial condition of a property (e.g., structures, crops or even large automobiles) in order to produce risk-assessment reports for underwriters and clients, which can then be used to determine appropriate pricing.¹⁶⁸ Before drone implementation, insurance companies used field personnel to “climb ladders and scaffoldings to inspect property” or walk across fields to inspect crops.¹⁶⁹ Now, drones can rapidly be deployed up front, significantly reducing the turn-around time for completing initial risk-assessment reports.¹⁷⁰

As the technology advances, more insurance companies will seek to deploy drones as essential business tools for claim adjudication, risk engineering and catastrophe claims management.¹⁷¹ Insurers that fail to introduce drones into their business models will quickly become dinosaurs in the field.¹⁷² Of course, for the insurance industry to take this next step, the FAA must assist in these efforts by allowing insurers a more streamlined approach to receiving waivers.

5. *Photography and Videography in Marketing*

As technology in drone cameras and navigation improve, many industries are lining up to employ the devices to create stunning visual content for use in marketing. The new gold standard in drone cameras utilizes one-inch sensors and 4K resolution, which provide superior quality imagery compared to anything previously in use at a remarkably affordable cost.¹⁷³ Additionally, drones are relatively easy to fly—even for a novice pilot—and can hover completely motionless to capture perfect videos and images that prior technology did not easily permit.¹⁷⁴ With these capabilities, marketing firms and photographers can enhance their storytelling abilities, capture previously unseen content, and establish an edge over their competition.¹⁷⁵ Not surprisingly then, drones are becoming widely used in media and marketing campaigns within the entertainment, advertising, real estate, and tourism industries.

168. Tayal & Ramani, *supra* note 152; AGIL FRANCIS ET AL., COGNIZANT, DRONES: THE INSURANCE INDUSTRY’S NEXT GAME-CHANGER? (2014), <https://perma.cc/M78M-NYLR>.

169. Tayal & Ramani, *supra* note 152; FRANCIS ET AL., *supra* note 168.

170. Tayal & Ramani, *supra* note 152; FRANCIS ET AL., *supra* note 168.

171. Tayal & Ramani, *supra* note 152; FRANCIS ET AL., *supra* note 168.

172. Tayal & Ramani, *supra* note 152; FRANCIS ET AL., *supra* note 168.

173. Charles Chen, *8 Crucial Things To Know Before Buying a Drone for Photography*, DJI GUIDES (Aug. 1, 2017), <https://perma.cc/W94Z-5JMD>; Nick Pino & Henry St. Leger, *What Is 4K Resolution? Our Guide to Ultra HD Displays*, TECHRADAR (Oct. 7, 2019), <https://perma.cc/HS6K-8YPW>. Sensors directly affect image quality and enables users to shoot high-quality footage in low light. 4K resolution has over 8 million pixels, which creates unparalleled picture and video quality. *Id.*

174. Chen, *supra* note 173.

175. Christina Brown, *Drones in Marketing: A New Era in Visual Marketing*, SAVY AGENCY (Jul. 6, 2016), <https://perma.cc/6RD6-6NE5>.

B. *Entertainment*

Because drones provide jaw-dropping photos and cinema-quality visuals, media companies have begun to integrate drone videography and photography into their operations. For example, the wildly popular environmental documentary series, *Planet Earth*, now regularly employs drones for its filming needs.¹⁷⁶ The producers send drones with high-quality cameras into the jungle to give their viewers a surreal nature experience.¹⁷⁷ Because 90% of jungle animals live up in the tree top canopy, drones fly hundreds of feet high to capture never-before-seen footage of animals that only a bird or aircraft could witness previously.¹⁷⁸

Drones are also becoming more frequently used to create captivating entertainment that doubles as advertising. For instance, Red Bull used drones to film “The Ridge,” a video short which featured professional cyclist Danny MacAskill.¹⁷⁹ In the YouTube video, MacAskill takes a “death-defying ride along the notorious Cuillin Ridgeline” in Scotland on his mountain bike.¹⁸⁰ The amazing aerial video cemented Red Bull’s “Red Bull gives you wings” slogan and captured the eyes of a staggering 61 million viewers.¹⁸¹ Additionally, Coca-Cola partnered with the Singapore Kindness Movement and filmed “Happiness from the Skies,” a campaign that helped provide Singaporeans the opportunity to show appreciation towards the foreign workers in their communities.¹⁸² That video showed drones delivering Coca-Cola cans and more than 2700 personalized thank you cards to migrant workers building structures in Singapore.¹⁸³ Coca-Cola used drone technology as an innovative way to “bring together two segments of the community who rarely interact.”¹⁸⁴ Any efforts by Coca-Cola (or Red Bull) to recreate this scene in the United States would have been marred with FAA-imposed red tape.

Finally, drones were used to great fanfare during Lady Gaga’s Super Bowl LI halftime show in 2017.¹⁸⁵ In unison, 300 drones danced behind the multiple Grammy winning music icon to form the American flag and Pepsi logo.¹⁸⁶ These drones provided a powerful performance on America’s biggest stage because of

176. *Planet Earth II—Drones in the Jungle*, BBC, <https://perma.cc/X82F-EKT8> (archived Nov. 7, 2019).

177. *Id.*

178. *Id.*

179. *How Drones Are Taking the Marketing Game Up and High*, 42WORKS (Jul. 26, 2017), <https://perma.cc/DP3A-Z2R2>.

180. Danny Macaskill, *The Ridge*, YOUTUBE (Oct. 2, 2014), <https://perma.cc/AYC8-C2T4>.

181. *Id.*

182. *How Drones Are Taking the Marketing Game Up and High*, *supra* note 179.

183. Press Release, CocaCola Co., *Happiness From the Skies: Watch Coke Drones Refresh Guest Workers in Singapore* (May 12, 2014), <https://perma.cc/7SBR-DM7E>.

184. *Id.*

185. Alex Fitzpatrick, *Here’s How Lady Gaga’s Super Bowl Drones Worked*, TIME (Feb. 6, 2017), <https://perma.cc/8GAM-388R>.

186. *Id.*

Intel's Shooting Star program, which preprogrammed the drones to fly, hover, and emit lights in a specific pattern.¹⁸⁷ This type of entertainment was "something that had never been done before" and was a combination of "Intel drone innovation with [Lady Gaga's] artistry."¹⁸⁸ Of course, it required a lengthy FAA preapproval process by satisfied first, a requirement that precludes more routine use.

C. Real Estate Marketing

For real estate agents, drone photography is increasingly providing potential buyers with information and details beyond simply aerial images of the entire property.¹⁸⁹ For example, drones can give potential buyers information about the surrounding neighborhood and area, driving routes to school or work from the property, and confirm the condition of the roof and other property features that are otherwise difficult and expensive to access.¹⁹⁰ Drones effectively streamline real estate transactions, provide plentiful visual information for a reasonable cost, and reduce unnecessary back-and-forth inquiries between parties about the property and surrounding area.¹⁹¹

Before drones were available, real estate agents obtained aerial photos of properties through satellite images or aerial photography sessions with hired airplanes or helicopters—both of which are prohibitively expensive and time-consuming.¹⁹² Luckily, drones provide a budget-friendly alternative.¹⁹³ Because of these efficiencies, real estate giants like Zillow and Trulia have integrated drone photography into their real estate operations.¹⁹⁴

Recently, Trulia launched Trulia Neighborhoods, "an aggregated dashboard of drone footage, photo galleries, reviews, photography, and information about

187. Matt Burns, *Intel Powered the Drones During Lady Gaga's Super Bowl Halftime Show*, TECHCRUNCH (Feb. 5, 2017), <https://perma.cc/HM4W-5SJQ>.

188. *Intel Drones Light Up Lady Gaga Performance During Pepsi Zero Sugar Super Bowl LI Halftime*, INTEL NEWSROOM (Feb. 5, 2017), <https://perma.cc/BRB3-RFLY>.

189. Tyler Nicely, *Real Estate Drone Photography and Video*, ZILLOW (May 21, 2019), <https://perma.cc/TYB2-QN64>.

190. *Id.* For example, many home inspectors now prefer to use drones to visualize rooftops, and pass on the savings to customers (not to mention improved safety to themselves).

191. See Ilyce Glink, *9 Ways Drones Are Changing Real Estate*, CBS (Mar. 6, 2017), <https://perma.cc/SVU7-JCQ8>.

192. *Id.*

193. *Id.* ("VHT Studios, based in Rosemont, Illinois, offers drone photography sessions starting at \$379 for up to 10 still photos and \$479 for photos and a one-minute video. Open Homes Photography, based in California's Bay Area, offers almost identical aerial drone photo packages for \$275 and \$575, respectively. In Brick Township, New Jersey, photography and video company Osprey Perspectives offers a 'basic' aerial drone photo package for \$250 and a 'basic' aerial video package for \$425.")

194. Kyle Wiggers, *Trulia Neighborhoods Gives Homebuyers a Drone's Eye View on Their New Neighborhood*, VENTUREBEAT (Aug. 14, 2018), <https://perma.cc/S5NY-SDFS>.

neighborhood communities.”¹⁹⁵ Based on research, Trulia found that “consumers were determined to find this type of information and even developed a series of hacks to source these valuable insights.”¹⁹⁶ In fact, the study found that 85% of homebuyers prioritize information about their prospective neighborhood when searching for new properties.¹⁹⁷ Fortunately, drone imagery and data give potential buyers enough information to digitally place them at the property site and its surrounding neighborhoods without physically having to even be there in person.

As of 2017, 26% of all small commercial drones were used for real estate purposes.¹⁹⁸ As a major application, drone usage in real estate is expected to increase but is limited due to FAA regulations.¹⁹⁹ Current restrictions require drone operators to obtain permits for commercial purposes.²⁰⁰ Unfortunately, the FAA issues permit on a case-by-case process, which make the acquisitions a burdensome and time-consuming process. Because of strict regulatory hurdles, it is “common practice for photographers and real estate agents to sidestep the federal regulations by charging only for video editing services, not the drone flights,” according to Zillow.²⁰¹

195. *Id.*

196. *Id.*

197. *Id.*

198. FED. AVIATION ADMIN., FAA AEROSPACE FORECAST: FISCAL YEARS 2017-2037 (2017), <https://perma.cc/PP6L-ZK8R>.

199. Joel Aschbrenner, *FAA Says Real Estate Agents' Drone Use Illegal*, USA TODAY (Jul. 7, 2014), <https://perma.cc/BH5V-DR54>.

200. 14 C.F.R. §§ 107.200 (2019); *see also Part 107 Waivers*, *supra* note 150.

201. Jennifer Chan, *Drones Take Off in Real Estate Marketing*, ZILLOW (June 27, 2014), <https://perma.cc/K726-Y3RX>.

D. Tourism

As the world becomes more digital, tourist information and advertising is increasingly shifting towards online social media platforms like YouTube, Facebook, and Instagram.²⁰² According to Google, two out of three American consumers are drawn towards these types of websites to watch travel videos.²⁰³ Understandably, travelers want to see a video of facilities, features, and location in advance of making their choices.²⁰⁴ As proof of this trend, travel vlogs “receive [four times] more social engagement (likes, comments, shares, favorites, subscriptions) than any other type of travel content on YouTube.”²⁰⁵ Because of these numbers, major players in the tourism industry have integrated drones into their online operations to capture breathtaking imagery and videos.

Effective social media boils down to the ability to create dramatic content that grabs viewers’ attention, which not surprisingly is aided by the inclusion of stunning visual imagery and videos that drones can provide. With scale and wide view photography and videos, prospective travelers can enjoy a realistic and persuasive view of their desired destination in advance of their decision to commit thousands of hard-earned dollars. Tourism advertisers and social media users have shared unbelievable videos of the Prince William Sound in the Gulf of Alaska where humpback whales and seals feed on fish,²⁰⁶ Big Sur in California where the

202. Vloggers (i.e., video bloggers) and advertisers are channeling resources into these platforms: Instagram is projected to have over 111 million users in the United States in 2019, J. Clement, *Number of Monthly Active Instagram Users 2013-2018*, STATISTA (2019), <https://perma.cc/K8J6-6RC5>, YouTube has over 1.8 billion users every month; and Facebook has over 2 billion users, Ben Gilbert, *YouTube Now Has Over 1.8 Billion Users Every Month, Within Spitting Distance of Facebook’s 2 Billion*, BUS. INSIDER (May 4, 2018), <https://perma.cc/26HN-RBE4>. In fact, the pictures and videos streaming on social media are changing the tourism industry, especially among millennials. More than 40% of travelers under 33 prioritize “Instagrammability” when choosing their next travel destination, which means how picture-worthy a destination is. Andrew Arnold, *Here’s How Much Instagram Likes Influence Millennials’ Choice of Travel Destinations* (Jan. 24, 2018), <https://perma.cc/78LV-HF69>. Additionally, Instagram users follow photographers on Instagram because their photo or video gives a “more genuine expression than looking for inspiration in a tourism brochure.” Carrie Miller, *How Instagram Is Changing Travel*, NAT’L GEOGRAPHIC (Jan. 26, 2017), <https://perma.cc/8B22-B2GU>. Whether travelers are looking for a picture-worthy or thrilling and intimate destination, social media provides a premium market for drone imagery and videos—travelers want to emotionally engage with photographers and experience their stories vicariously through their photos or videos according to Google. Hailey Crowel et al., *Travel Content Takes Off on YouTube*, THINK WITH GOOGLE (Aug. 2014), <https://perma.cc/A2VP-62Y2>.

203. *Tourism Marketing with Videos: Make that Emotional Connection*, TOMAHAWK (May 15, 2017), <https://perma.cc/SAC5-Z6BY>; Crowel et al., *supra* note 202; *How Video Can Benefit Tourism Marketing*, ONE PRODUCTIONS (July 31, 2013), <https://perma.cc/PMY9-Y6K3>.

204. TOMAHAWK, *supra* note 203; ONE PRODUCTIONS, *supra* note 203.

205. Crowel et al., *supra* note 202.

206. Gavin Hobbs, *7 Places To Capture With Your Drone*, CREATIVE TRAVEL GUIDE (Jun. 7, 2018), <https://perma.cc/7XTN-26GN>.

Pacific Ocean's waves crash into seaside cliffs,²⁰⁷ and Black Hills in South Dakota where wild bison, bighorns, and other wildlife roam the forest, mountains, and peaks.²⁰⁸ Additionally, major travel brands utilize professional drone videos to showcase exciting tourist destinations: 67% of travel-related YouTube views are from major companies such as Expedia and Disney Parks & Resorts.²⁰⁹ For the foreseeable future, the tourism industry will continue to embrace drone videos and photography on the internet and social media in order to aid and persuade travelers in picking their next travel destination.

E. Rescue and Recovery After Accidents and Disasters

When disaster strikes, drones can save lives by aiding first responders in search, recovery and humanitarian efforts. Traditionally, human rescue teams have searched for disaster victims or wreckage in deserts, oceans, mountains, and forests, consuming precious time and energy and risking even greater loss of life.²¹⁰ Even when rescuers locate survivors, the teams are tasked to recover victims in dangerous areas that may contain chemical, biological, radiological, nuclear, or explosive materials or in vast and rough terrain.²¹¹ These efforts also carry significant financial expense, as helicopters, other large machinery (e.g., cameras), and a team of rescuers are often deployed for these missions today.²¹²

Fortunately, drones are a better fit to handle these dire situations for three reasons. First, drone operators are not forced to weigh lives like a helicopter pilot might, enhancing the effectiveness of search and rescue operations and reducing the likelihood of human error and injury in terrifying situations.²¹³ Second, human fatigue can be removed as a factor in recovery efforts, and society can avoid putting first responders in harm's way.²¹⁴ Finally, drones are far less expensive and more effective than helicopters.²¹⁵

In these dire situations, a drone's lifesaving potential is not mere speculation—drones have saved at least 133 lives worldwide as of June 2018.²¹⁶ DJI, a global leader in drone and aerial imaging technology, now estimates that drones

207. *Id.*

208. *Id.*

209. Crowel et al., *supra* note 202.

210. MEASURE, DRONES FOR DISASTER RESPONSE AND RELIEF OPERATIONS 27 (2015), <https://perma.cc/529M-VW5P>.

211. *Id.*

212. *See id.*; Charles W. Bryant, *The Cost of Search and Rescue*, HOWSTUFFWORKS, <https://perma.cc/3YKC-HPPL> (archived Feb. 28, 2020); Aarian Marshall, *Above Devasted Houston, Armies of Drones Prove Their Worth*, WIRED (Sept. 4, 2017), <https://perma.cc/R4AB-RECU>.

213. *See* Marshall, *supra* note 212.

214. MEASURE, *supra* note 210 at 27.

215. *See* Marshall, *supra* note 212.

216. Press Release, DJI, Public Safety Drones Save Four Lives in One Day (Jun. 6, 2018), <https://perma.cc/C494-FE27>.

save “one person’s life a week on average.”²¹⁷ One recent example in Canada involved police officers utilizing drone technology equipped with infrared imaging to locate an injured driver who was stranded in a snowy bank after a helicopter search had failed to turn up anything.²¹⁸ In another dramatic example, a drone located the victim of a heart attack and his granddaughter who were stranded on the Des Moines River.²¹⁹ In that rescue mission, the drone located the two victims well before a 20-person rescue team did.²²⁰ Time is critical in rescue missions like this, as the sun was setting and darkness made it difficult for human rescuers to see the victims amid the thickly wooded riverbank.²²¹ Yet another success story came in 2017 when rescuers found missing and stranded kayakers near Huntington Beach using a heat-sensing drone.²²²

Furthermore, police and fire departments also utilize drones for disaster relief to locate helpless individuals and deliver life-saving supplies. For example, public safety agents in Texas dropped a life vest to a mother and her fifteen-year-old daughter who were stranded in a rising river and did not know how to swim.²²³ Additionally, U.K. police officers used a drone with a thermal imaging camera to find an unconscious man at the edge of a steep cliff face.²²⁴ These are but a couple of the increasing number of success stories touting the efficacy and safety of drones in search and rescue missions due to their ability to cover significantly more area than humans, and their ability to use thermal imaging cameras to locate stranded, missing, or unconscious individuals hidden by smoke, vegetation, or darkness.²²⁵

Moreover, in response to natural disasters, drones have also proven to be powerful tools. With the FAA’s authorization, over 100 drones were deployed in Houston, Texas after Category 4 Hurricane Harvey hit.²²⁶ These drones inspected roadways and evaluated the condition of water plants, oil refineries and power

217. Don Reisinger, *Here’s How Many Lives Drones Have Saved Since 2013*, FORTUNE (Mar. 14, 2017), <https://perma.cc/TV5R-FVK5>.

218. *Id.*; Carl Franzen, *Canadian Mounties Claim First Person’s Life Saved by a Police Drone*, THE VERGE (May 10, 2013), <https://perma.cc/E8ME-C5GL>; Keith Nelson Jr., *Drones Can Help When Disaster Strikes, but Only When They’re Allowed To*, DIGITAL TRENDS (Sept. 28, 2017), <https://perma.cc/C9RH-XU7V>.

219. Matt McFarland, *Drone Helps Find Man Suffering from Heart Attack*, CNN MONEY (Jul. 15, 2016), <https://perma.cc/MGE2-ZYSC>.

220. *Id.*

221. *Id.*

222. *Midway Fire Rescue Uses Thermal Imaging To Rescue Kayakers*, WPDE NEWS (Jan. 17, 2017), <https://perma.cc/89CJ-926E>.

223. Rissa Shaw, *Drone Used To Help Rescue 4 Stranded in Brazos; Dam Gates Closed*, KWTX (May 31, 2018), <https://perma.cc/Z5BZ-S69R>.

224. @PoliceDrones, TWITTER (Jun. 25, 2018), <https://perma.cc/7SW8-GYE7>.

225. *Public Safety Drones Save Four Lives in One Day*, *supra* note 216.

226. Andy Pasztor, *Drones Play Increasing Role in Harvey Recovery Efforts*, WALL ST. J. (Sept. 4, 2017), <https://perma.cc/P5GR-7GCU>; *Hurricane Harvey Aftermath*, CNN, <https://perma.cc/3GTG-KQJY> (archived Oct. 5, 2019).

lines.²²⁷ In addition, drones were used to locate stranded individuals and offer quick assessments of flood damage so that resources could be triaged to their most needed location.²²⁸

Yet, these applications cannot be fully utilized in the United States without the FAA's advance permission. For example, the FAA limited drone applications after the aforementioned Hurricane Harvey.²²⁹ Of course, the FAA's restriction was implemented because the agency wanted human first responders to have as much airspace to operate as possible.²³⁰ However, this catastrophe and the accompanying flight restrictions placed on drones demonstrated the unfortunate reality that drones are still not the first choice when it comes to search and rescue despite their substantial comparative advantages on their human counterparts.

In response to criticism after Hurricane Harvey, the FAA now issues some single, blanket authorizations to fly different types of drones for various humanitarian missions to reduce delays and bureaucratic processes.²³¹ However, many critics, including the Small UAV Coalition, still call for greater regulatory flexibility to achieve the immense potential of drones to help first responders and the public when crisis hits.

F. *Blood and Medical Supply Delivery*

Compared to the United States, other countries have implemented far greater use of drones to deliver emergency equipment and supplies to the world's hard-to-reach areas. For example, Zipline, a U.S. startup (with none other than U2 legend Bono on its Board), has partnered with the Rwandan government to utilize drones to deliver blood supplies.²³² Before this partnership, some patients were forced to wait at least three hours to obtain blood transfusions.²³³ Unfortunately, "[t]hree hours can make the difference between saving or losing a life."²³⁴ Luckily

227. Pasztor, *supra* note 226.

228. Matthew Hutson, *Hurricanes Show Why Drones Are the Future of Disaster Relief*, NBC NEWS (Sept 9, 2017), <https://perma.cc/3CXG-TYFM>.

229. Nelson, *supra* note 218.

230. Nelson, *supra* note 218.

231. Pasztor, *supra* note 226.

232. Aryn Baker, *The American Drones Saving Lives in Rwanda*, TIME, <https://perma.cc/5YUU-R282> (archived Oct. 5, 2019); Zipline, CRUNCHBASE, <https://perma.cc/AVE9-KT6T> (archived Feb. 28, 2020).

233. Baker, *supra* note 232; Robert Lee Hotz, *In Rwanda, Drone Deliver Medical Supplies to Remote Areas*, WALL ST. J. (Dec. 1, 2017), <https://perma.cc/U8MR-C3T3>.

234. Baker, *supra* note 232. In medicine, physicians refer to the first hour after traumatic injury as the "golden hour," reflecting the fact that immediate medical attention is often needed to dramatically improve the chances of saving lives and reducing the severity of injury. Charlie Eisele, *The Golden Hour*, J. EMERGENCY MED. SERVS. (Aug. 31, 2008), <https://perma.cc/PW3C-EPXJ> (discussing R. Adams Cowley's pioneering discussion of the crucial first 60 minutes after traumatic injury).

with drone delivery, hospitals in Rwanda (e.g., Nyanza Hospital and Kabgayi Hospital) can get access to blood within fifteen minutes.²³⁵

This quick response time recently saved a two-year-old girl when her critical blood delivery arrived via a drone from a blood bank flown directly to the hospital where she was being treated.²³⁶ Like a scene out of a Hollywood movie, the drone flew over the hospital and dropped a red cardboard box attached to a parachute nearby, and delivered two packets of blood wrapped in insulating paper.²³⁷ Zipline has delivered more than 4,000 units of blood products (e.g., red blood cells, platelets, and plasma) to twelve different hospitals across Rwanda since December 2016.²³⁸ The success of Zipline in Rwanda has led to its expansion into other countries such as Tanzania and even Ghana, where Zipline will earn more than \$12 million on a four-year deal with Ghana's government.²³⁹

Beyond blood deliveries, drones can deliver other medical necessities.²⁴⁰ Recently, Swiss Post launched a medical transport network in Lugano, Switzerland, which has made 350 medical supply deliveries.²⁴¹ Swiss Post's drone delivery project has delivered laboratory samples between University Hospital Zurich and the Irchel Campus of the University of Zurich.²⁴² These deliveries employ drones that are flown autonomously from one location to the next, significantly cutting waiting times for patients and doctors when every second counts.²⁴³

Unfortunately, due to FAA restrictions, these same lifesaving applications cannot be implemented in the United States.²⁴⁴ Simply put, the FAA's line-of-sight regulation costs lives. No patient should die because their lifesaving treatment is stuck in traffic. It is evident that the FAA's focus concentrates far more on the risks of integrating drones into the national airspace rather than on the benefits that drones provide (or, more importantly, the *opportunity costs* of not utilizing modern technology). As industry expert Susan Roberts recently said, "It doesn't do anybody any good for a delivery company to be able to fly from two specific points [autonomously] if they can't then scale that over and over again."²⁴⁵ With

235. Baker, *supra* note 232; Hotz, *supra* note 233.

236. Baker, *supra* note 232.

237. *Id.*

238. *Id.*

239. Taylor, *supra* note 2; BBC, *Ghana Drones: Row over Blood-Delivery Devices* (Dec. 12, 2018), <https://perma.cc/7R5C-NAFY>; Jack Stewart, *Zipline Launches Medical Supply Drone Deliveries in Tanzania*, WIRE (Apr. 24, 2017), <https://perma.cc/ZCP9-NAHZ>.

240. Esther Landhuis, *Medical Cargo Could Be the Gateway for Routine Drone Deliveries*, NPR (Mar. 10, 2018), <https://perma.cc/GE53-QXBH>.

241. *Id.*

242. *Swiss Post To Use Drones for Lab Sample Deliveries in Zurich*, THE LOCAL (Dec. 5, 2018), <https://perma.cc/539X-M7XV>.

243. *Id.*; *Postdrone Transportiert Laborproben Zwischen dem UniversitätsSpital und der Universität Zürich*, DIE POST (Apr. 12, 2018), <https://perma.cc/4VKJ-PRNA>.

244. Landhuis, *supra* note 240.

245. *Id.*

its strict regulatory hurdles, the FAA is not only hindering life-saving drone applications, but also deterring American companies from investing more into drone technologies.

Conversely, if the FAA were to adopt more flexible regulatory policies, drones could easily deliver medical supplies and lab tests, assisting doctors in diagnosing infections and prescribing medications, with life-or-death implications.²⁴⁶ Dr. Geoff Baird, clinical pathologist at the University of Washington (UW), recently addressed the lost opportunities due the inability to use drones to quickly transmit blood, urine, and swab samples.²⁴⁷ Without drones, transferring specimens to the UW testing facility is done by car, which creates far longer turn-around times, especially if facilities test for out-of-state hospitals and clinics.²⁴⁸ For instance, UW runs tests for hospitals and clinics in rural communities on the San Juan Islands off the northwest coast of Washington.²⁴⁹ To get samples from the island to UW can take more than 24 hours, even though it is only 100 miles as the crow flies.²⁵⁰ However, that same delivery could be executed within 90 minutes by drone—if FAA regulations permitted it.²⁵¹

G. Scientific Research

Researchers are also utilizing drones to advance and modernize the methods for scientific research. As discussed, drones can maneuver around difficult-to-reach places and cover vast landscapes to capture detailed imagery with their high-tech cameras. Scientists and conservationists can use the resulting images to identify plants and animals; thermal cameras to detect living animals or stressed plants; and hyperspectral imaging to identify measurements through reflected light unseen by human eyes.²⁵² These drone applications have the potential to democratize scientific information and further advance research.

For example, scientists from the Earth Institute's Lamont-Doherty Earth Observatory, a research unit of Columbia University, are beginning to use drones to revolutionize their research.²⁵³ Alessio Rovere, an adjunct research scientist at Lamont-Doherty, uses drones to study coastal erosion, which includes corals distribution and death.²⁵⁴ Rovere deploys his drone to take multiple pictures of coastal areas and then merges those pictures with software and algorithms.²⁵⁵ This process is repeated to depict a "seamless image of the area and a 3-D digital elevation

246. *Id.*

247. *Id.*

248. *Id.*

249. *Id.*

250. Landhuis, *supra* note 240.

251. *Id.*

252. Cho, *supra* note 23.

253. *Id.*

254. *Id.*

255. *Id.*

model,” which shows changes in coastal conditions – which is otherwise difficult to capture with prior technology because coastal areas rapidly change.²⁵⁶ Additionally, Einat Lev, an assistant research professor at Lamont-Doherty, uses drones to study volcanoes to improve eruption hazard assessment.²⁵⁷ Lev’s drone captures images of volcanoes and molten lava to create a 3D digital topographic map, which is a dangerous and difficult task to undertake without drones.²⁵⁸

Drones also open more research opportunities as technology advances. Christopher Zappa, an associate research professor at Lamont-Doherty, “studies how the atmosphere generates waves through wind, how waves break, and how that energy injected into the ocean affects the transfer of gases, heat and energy between the ocean and the atmosphere,” among other projects like developing a sea ice radar, which will measure sea ice thickness using drone technology.²⁵⁹ Zappa is able to further his studies in these areas using drones (instead of “ships or manned aircraft[s]”).²⁶⁰ For example, he utilizes infrared imaging (which measures the temperature of any surface), visible hyperspectral cameras (which show when ice breaks up and sunlight penetrates surfaces), micro-drifters (which analyze atmospheric temperature, water vapor, and pressure), and broadband long wave/short wave radiation (which measures solar energy from the sun).²⁶¹ Crucially, Zappa can efficiently collect the necessary data in an “undisturbed ocean” and “get away from [using ships and helicopters] that may or may not affect the environment.”²⁶²

Moreover, drones have allowed scientists to efficiently and economically collect data and perform tasks such as prescribing fires to eradicate invasive species or assisting in measuring air pollution emitted by industrial smokestacks.²⁶³ Drones can serve a crucial role in advancing all methods of scientific data collection—a paramount foundation for scientific research—but regulations such as the FAA’s visual line-of-sight rule drastically limit the size of the area that can be studied, and hence substantially reduce the practical utility of drones.

H. *Animal Conservation Efforts*

Labelled as a “game-changer,” drones are revolutionizing how scientists and ecologists collect data to aid in animal conservation and protection efforts.²⁶⁴ Ac-

256. *Id.*

257. *Id.*

258. Cho, *supra* note 23.

259. *Id.*

260. *Id.*

261. *Id.*

262. *Id.*

263. *Id.*

264. Jared Hodgson et al., *When It Comes to Counting Wildlife, Drones Are More Accurate than People*, THE SMITHSONIAN (Feb. 27, 2018), <https://perma.cc/R7YH-3LYF>.

cess to accurate and reliable data helps scientists and ecologists understand animals, much like how data helps technology companies better understand their business, customers, and opportunities.²⁶⁵ With drones, scientists and ecologists can remotely monitor animals and collect accurate data.²⁶⁶ Accordingly, scientists can “estimate the health of fragile polar mosses, [] measure and predict the mass of leopard seals, and even [] collect whale snot.”²⁶⁷ Endangered animals across the globe can benefit from drone technology because the devices provide far more accurate data than what was previously available to assess animal populations and health²⁶⁸ without harming sensitive ecosystems. Specifically, scientists and ecologists can now use drones to collect highly accurate data without disturbing animals in order to combat against poaching and reduce extinction rates.²⁶⁹

Drone-derived data is also more accurate than human-procured data.²⁷⁰ For example, the Smithsonian Institution’s #EpicDuckChallenge tested how accurately drones and humans could count a population of ducks by creating a contest that involved placing thousands of fake ducks on the ground.²⁷¹ After multiple trials, researchers found that the drone-derived counting data was up to 96% more accurate than human-derived data,²⁷² and produced more consistent population counts as well.²⁷³ Because determining the exact number of animals in a wild population is difficult, maybe even impossible in some situations, gathering reliable sampling data is extremely important.²⁷⁴ Not surprisingly, the drones provided more accurate and consistent data because the devices have an optimal vantage point and can capture high-resolution photos, which allow scientists to “digitally review their counts as many times as they needed” to reduce the likelihood of error.²⁷⁵

Additionally, drones can inconspicuously collect reliable information from animals to monitor their health without unduly disturbing them. For example, scientists can monitor and assess ocean animals to aid in population restoration

265. See, e.g., *Technology for Good*, PAUL ALLEN (Jul. 14, 2016), <https://perma.cc/N76N-X3AK>.

266. Kike Calvo, *So You Want To Fly Drones for Conservation?*, NAT’L GEOGRAPHIC (May 17, 2017), <https://perma.cc/T58J-2GA7>; Hodgson et al., *supra* note 264.

267. Hodgson et al., *supra* note 264; see Calvo, *supra* note 266.

268. Hodgson et al., *supra* note 264.

269. Rachel Nuwer, *High Above, Drones Keep Watchful Eyes on Wildlife in Africa*, N.Y. TIMES (Mar. 13, 2017), <https://perma.cc/2EGE-G69W>; Justin Worland, *Drones Are Helping Catch Poachers Operating Under Cover of Darkness*, TIME (May 31, 2018), <https://perma.cc/WU22-9HNB>.

270. Hodgson et al., *supra* note 264.

271. *Id.*

272. *Id.*

273. *Id.*

274. Kaya Yurieff, *Drones Are Helping Scientists Fight Wildlife Extinction*, CNN MONEY (Feb. 13, 2018), <https://perma.cc/D2M6-EEFH>; Hodgson et al., *supra* note 264.

275. Hodgson et al., *supra* note 264.

and preservation.²⁷⁶ In particular, drones can monitor when whales surface and then collect their nasal discharge, which is a safe and non-invasive way to study the animal's health.²⁷⁷ A whale's nasal discharge reveals crucial details about the mammal, such as DNA, stress and pregnancy hormones, viruses, bacteria, and toxins.²⁷⁸ During a recent "snot-collecting" mission, which was featured in National Geographic, researchers deployed drones from a nearby ship and collected whale samples with its "SnotBot."²⁷⁹ These scientists analyzed the discharge using artificial intelligence to produce real-time data for their research and conservation initiative.²⁸⁰ Without drones, these tasks would be prohibitively difficult, expensive, invasive, and dangerous to undertake.

Similarly, drones can also benignly monitor and collect data from animals facing extinction.²⁸¹ For example, WildTrack, a nonprofit organization dedicated to non-invasive animal tracking, utilizes drones to count footprints for this purpose.²⁸² WildTrack uses a proprietary footprint monitoring technique to identify an animal's species, sex, and age without disturbing the animal.²⁸³ This technique requires precise digital images of animal footprints, and drones provide the most efficient way to collect them.²⁸⁴ Additionally, drones reduce the turnaround time to accurately locate these footprints across difficult-to-reach habitats.²⁸⁵

Finally, drone technology can provide an immediate impact in curbing illegal poaching—a primary reason for the decline of animal populations.²⁸⁶ African elephants and rhinos are on the verge of extinction because the demand for their

276. Press Release, Intel, From Polar Bears to Whales, Intel Pushes the Boundaries of Wildlife Research with Drone and Artificial Intelligence (Oct. 4, 2017), <https://perma.cc/SC4S-XUJH> [hereinafter Intel]; Alyson Griffin, 'SnotBots,' Whales, and the Health of Humanity, IT PEER NETWORK (Jun. 8, 2017), <https://perma.cc/2JW2-XWT6>.

277. Intel, *supra* note 276; Griffin, *supra* note 276.

278. Griffin, *supra* note 276.

279. Intel, *supra* note 276; National Geographic, *Scientists Fly a Drone To Collect Whale Snot*, YOUTUBE (July 13, 2017), <https://perma.cc/X6SM-HTFS>; Matthew Mulrennan, *8 Breakthrough Innovations Saving Our Oceans*, NATIONAL GEOGRAPHIC (June 8, 2016), <https://perma.cc/Q2VR-JP2F>.

280. Intel, *supra* note 276.

281. See Jarrod C. Hodgson et al., *Precision Wildlife Monitoring Using Unmanned Aerial Vehicles*, 6 SCI. REP. 1 (2016); Yurieff, *supra* note 274; Anthea Lipsett, *Drones and Big Data: The Next Frontier in the Fight Against Wildlife Extinction*, THE GUARDIAN (Feb. 18, 2019), <https://perma.cc/K2J3-6V4N>.

282. Alejandro De La Garza, *These Researchers Are Using AI Drones to More Safely Track Wildlife*, TIME (Nov. 1, 2019), <https://perma.cc/EJL7-HK7V>.

283. *Id.*

284. De La Garza, *supra* note 282; see also Press Release, Duke Univ., New Project Uses Phones and Drones To Monitor Endangered Species (May 22, 2017), <https://perma.cc/8G4L-N39N>.

285. De La Garza, *supra* note 282; see also Jani Actman, *Poaching Animals, Explained*, NAT'L GEOGRAPHIC (Feb. 12, 2019), <https://perma.cc/LF87-XUGY>; DUKE UNIV., *supra* note 284.

286. De La Garza, *supra* note 282; Actman, *supra* note 285.

tusks and horns is high among traders in the Chinese black market.²⁸⁷ This demand fuels organized crime and terrorist groups, as poachers have created an extremely lucrative market that generates approximately \$10 billion per year.²⁸⁸ Fortunately, drones can serve as an effective counter-measure by quickly detecting nocturnal poaching activities with their infrared cameras and then immediately notifying park rangers to intercept the perpetrators.²⁸⁹ They also have the potential to deter future poaching efforts by reducing the likelihood that poachers think they will escape.²⁹⁰

Hence, by employing drones for use in animal conservation and preservation efforts, researchers can have a positive impact on their subjects in a much less invasive manner than prior human contact studies entailed.²⁹¹ Non-invasive data collection is critical because changing the behavior or ecology of the animals being studied produces unreliable data and could be counterproductive to researchers' goals.²⁹² While there are some concerns on the other side about drone-produced stress to animals,²⁹³ this impact can largely be avoided by taking sensible precautions, such as flying at safe altitudes, optimizing flight patterns, and being conscious of the target species, among others.²⁹⁴ Additionally, a new study shows that drone use in conservation efforts (e.g., anti-poaching missions) "can provide benefits without long-term high-stress consequences."²⁹⁵ For example, the study showed that while bears showed initial signs of stress in response to drones, these bears "habituated to drones over a 3 to 4-week period."²⁹⁶

I. Law Enforcement

While the use of drones in law enforcement has sparked privacy concerns and fears of unwarranted surveillance among some,²⁹⁷ drones are proving to be

287. Actman, *supra* note 285; Lauren Neme, *Despite Ban, Rhino Horn Flooding Black Markets Across China*, NAT'L GEOGRAPHIC NEWS (Jul. 18, 2017), <https://perma.cc/W7YL-UYKM>.

288. Worland, *supra* note 269.

289. Nuwer, *supra* note 269.

290. *Id.*

291. Jesus Jimenez Lopez & Margarita Mulero-Pazmany, *Drones for Conservation in Protected Areas: Present and Future*, 3 DRONES 10 (2019).

292. *Id.*

293. See *infra* Part IV.D; *Bears Get "Stressed" by Drones*, BBC (Aug. 17, 2015), <https://perma.cc/D7SB-MP85>.

294. Margarita Mulero-Pazmany et al., *Unmanned Aircraft Systems as a New Source of Disturbance for Wildlife: A Systematic Review*, 12 PLOS ONE e0178448 (2017).

295. Mark A. Ditmer et al., *Bears Habituate to the Repeated Exposure of a Novel Stimulus, unmanned Aircraft Systems*, 7 CONSERVATION PHYSIOLOGY coy067 (2019); *Animals May Get Used to Drones*, SCIENCE DAILY (Jan. 15, 2019), <https://perma.cc/73K2-7JHY> (reporting on Ditmer's study).

296. *Animals May Get Used to Drones*, *supra* note 295.

297. JAY STANLEY & CATHERINE CRUMP, ACLU, PROTECTING PRIVACY FROM AERIAL

more useful than harmful in this arena. For example, drones can significantly reduce and expedite the workload of law enforcement officers by quickly surveying locations from above to document crime scenes, identify suspects or victims, and assess motor vehicles accidents and traffic.²⁹⁸ Because of these beneficial drone applications, over 900 state and local police, sheriff, fire, and emergency services agencies have integrated drones into their operations in the United States, according to a study conducted by Bard College.²⁹⁹ A staggering 63% of these drones are used by police departments.³⁰⁰ Simply put, drones are efficient and effective tools for crime prevention and public safety protection.

Recently, the New York Police Department (“NYPD”)—the nation’s largest police force—announced that it is adding drones to its arsenal of crime-fighting tools.³⁰¹ Primarily, the NYPD plans to use drones to create 3D digital models of crime scenes and traffic accidents.³⁰² It also plans to use drones for search and rescue missions, hazardous inspections, and hostage situations.³⁰³ Because of rising privacy concerns, however, NYPD’s Chief Terence Monahan emphasized that drones will not be used for warrantless surveillance.³⁰⁴ Other senior police officials have also stated that drones will not be used for routine surveillance, traffic enforcement, and immobilizing vehicles and suspects.³⁰⁵ Additionally, drones will not be armed with weapons or use facial recognition technology.³⁰⁶ Despite some public pushback, Commissioner James O’Neill insists that drones will enable NYPD’s “highly-trained cops to be even more responsive to the people [they] serve, and to carry out [their] critical work in ways that are more effective, efficient, and safe for everyone.”³⁰⁷

For example, law enforcement departments can deploy drones to efficiently mitigate the impact of traffic accidents.³⁰⁸ To clear a highway accident and free miles of backed up traffic, law enforcement officers must first measure, evaluate,

SURVEILLANCE: RECOMMENDATIONS FOR GOVERNMENT USE OF DRONE AIRCRAFT (2011), <https://perma.cc/N59Q-F3BG>.

298. Zacc Dukowitz, *6 Ways Police Departments Use Drones in Their Work*, UAV COACH (May 10, 2018), <https://perma.cc/4S39-EWAS>.

299. DAN GETTINGER, CTR. STUDY DRONE AT BARD C., PUBLIC SAFETY DRONES: AN UPDATE 1 (2018), <https://perma.cc/VF2R-HUPA>.

300. *Id.* at 2 (finding that “[o]f the 910 public safety agencies in [the] dataset, 302 are sheriff or country police (33 percent) [and] 278 are municipal police (30 percent).”).

301. Chris Franciscani & Aaron Katersky, *The NYPD, the Nation’s Largest Police Department, Puts Its Eyes in the Skies With New Drone Program*, ABC NEWS (Dec. 4, 2018), <https://perma.cc/62QB-QMRG>; Ashley Southall & Ali Winston, *New York Police Say They Will Deploy 14 Drones*, N.Y. TIMES (Dec. 4, 2018), <https://perma.cc/WJA3-ZC45>.

302. Franciscani & Katersky, *supra* note 301.

303. *Id.*

304. *Id.*; Southall & Winston, *supra* note 301.

305. *Id.*

306. Franciscani & Katersky, *supra* note 301; Southall & Winston, *supra* note 301.

307. Franciscani & Katersky, *supra* note 301.

308. *Id.*

and document the magnitude of the accident.³⁰⁹ This process may require emergency responders and crash investigators to shut down lanes or close entire roads, which place officials in danger of being struck by traffic³¹⁰ and may take hours.³¹¹ Fortunately, drones can accomplish the same tasks within minutes.³¹²

In lieu of sending officers to the crash site, law enforcement officials can remotely (and rapidly) deploy drones to the precise location to capture high-resolution photos.³¹³ These photos can be combined with other technologies to create 3D recreations of the crash site that quickly piece everything together for investigators.³¹⁴ For instance, within minutes a drone was able to survey a Illinois crash site involving a semi-tractor-trailer and a motor vehicle. Normally, this process would have taken three hours.³¹⁵ Similarly, North Carolina's transportation department and highway patrol collected traffic and accident data within twenty-five minutes during a simulation study.³¹⁶ Without drones, the simulation found that the department would need fifty-one minutes to collect and survey the same crash site.³¹⁷

Moreover, drones can reduce overspending on unnecessary police hours.³¹⁸ Because drones dramatically reduce the time it takes to analyze a car accident, costly overtime hours can be reduced.³¹⁹ For example, after thirty drone deployments in 2017, the Maine State Police Department estimated that it saved \$80,000 in reduced overtime hours.³²⁰ Thus, drones are already an invaluable tool in law enforcement efforts given their ability to quickly survey scenes, increase officer safety, and reduce exhausting overtime hours.

J. Recreational Drone Use

Drones are also becoming wildly popular among recreational hobbyists.³²¹ In fact, Goldman Sachs now estimates that the expanding consumer drone market

309. *Id.*

310. Jenni Bergal, *Look What's New on the Accident Investigation Team: Drones*, WASH. POST (Aug. 18, 2018), <https://perma.cc/29XK-YQ7S>.

311. *Id.*

312. Francescani & Katersky, *supra* note 301.

313. Bergal, *supra* note 310.

314. *Id.*

315. *Id.*

316. *Id.*

317. *Id.*

318. *Id.*

319. *Id.*

320. The Maine State Police department initially invested \$40,000 in drones and software and saved twice their initial investment in reduced overtime hours. *Id.*; Marco Margaritoff, *Drones as Crash Scene Analysis Tools are Rapidly Taking Off*, THE DRIVE (Aug. 7, 2018), <https://perma.cc/3HV8-SPAC>.

321. Jesse Maida, *Global Consumer Drones Market 2017-2021: Aerial Photography Segment Dominates the Global Market*, TECHNAVIO (Sept. 26, 2018), <https://perma.cc/WLS8-RQAN>.

will reach a whopping \$17 billion for 2016-2020.³²² In 2020 alone, Goldman Sachs estimates 7.8 million consumer drone shipments, equating to roughly \$3.3 billion in revenue.³²³ Moreover, the consumer drone market is the largest non-military market for drones, far surpassing that of the commercial and public safety markets.³²⁴ As this market grows, drone technology promises to offer amazing opportunities for recreational photography and videography, and even pure leisure.³²⁵

Specifically, consumer drones attract increasing attention because of their unparalleled ability to take breathtaking photos from various angles. See Figure 1 below. Amazingly, the stunning photo below, for example, did not “require a helicopter and a Michael Bay budget.”³²⁶



FIGURE 1. AERIAL SHOT OF THE TWIN LAGOON IN CORON ISLAND, PHILIPPINES.

Drones have made capturing high-quality, breathtaking photos easier for two reasons. First, most drones are already equipped with 4K Ultra HD resolution and

322. *Drones: Reporting for Work*, *supra* note 89.

323. *Id.*

324. *See generally, id.*

325. *See Global Consumer Drones Market 2017-2021*, BUSINESSWIRE (Sept. 26, 2018), <https://perma.cc/FZ25-A9C9>.

326. Geoffrey A. Fowler, *Let's Go Fly a Drone: The Best Vacation Pics Come from Above*, WALL ST. J. (May 16, 2014), <https://perma.cc/9GNB-SZ63>.

stabilized cameras for smooth videos and sharp photos.³²⁷ Second, drones are relatively easy to fly, even for novices. As technology improves, more drones are now equipped with “idiot-resistant” functions, such as: (1) Omnidirectional Obstacle Sensing (which prevents drones from crashing into obstacles and objects), (2) “Return to Home” functions (which automatically flies a drone back to its owner) and (3) ActiveTrack (which allows a drone to follow a subject like a boat, car, or person).³²⁸

In addition to easy-to-use, impressive technology, drone photography does not require years of cinema or photography experience. Manufacturers have created their own free or inexpensive drone photography classes, such as the DJI Aerial Photography Academy, and published books, such as *Aerial Photography and Videography Using Drones*.³²⁹ Within an hour of purchase, consumer drone operators can learn how to properly fly their drones and take a beautiful “dronie”—a spin-off of a “selfie” that PhotoJojo’s co-founder has popularized.³³⁰

Beyond photography and videography, drones are often flown acrobatically simply for fun and joy. In fact, drone races now fill content on ESPN television,³³¹ as teens and young adults navigate obstacle courses and perform aerial stunts at breathtaking speeds, often while using FPV technology instead of human eyes.³³²

For these reasons, it is not difficult to see why recreational drone use is growing rapidly.³³³ While safety is a rising concern, flying recreational drones “isn’t more dangerous than riding a bike.”³³⁴ In addition, technological advances further address safety concerns. For example, geofencing technology can help keep drones out of dangerous areas,³³⁵ parachutes prevent drones from uncontrollably

327. See, e.g., *DJI Mavic Pro & Mavic Pro Platinum*, DJI OFFICIAL, <https://perma.cc/UW3C-6YVC> (archived Jan. 5, 2020); *Drones 4K: Top Selected Products and Reviews*, AMAZON, <https://perma.cc/68CF-592Z> (archived Feb. 29, 2020).

328. See, e.g., *Mavic 2*, DJI OFFICIAL, <https://perma.cc/5CD9-3TGB> (archived Jan. 5, 2019); *GPS Drone with Return Home: Top Selected Products and Reviews*, AMAZON, <https://perma.cc/ARR3-5QNJ> (archived Feb. 29, 2020); DJI, *Film Like a Pro: DJI Drone “ActiveTrack”—With Video Tutorials*, DJI (Dec. 18, 2017), <https://perma.cc/9DL8-V7E7>.

329. *Home*, DJI AERIAL PHOTOGRAPHY ACAD., <https://perma.cc/EZ8V-ZP5T> (archived Jan. 5, 2020); ERIC CHENG, *AERIAL PHOTOGRAPHY AND VIDEOGRAPHY USING DRONES* (1st ed. 2015).

330. Fowler, *supra* note 326.

331. *Highlights from Season 2 of the Drone Racing League*, ESPN VIDEO (Nov. 16, 2017), <https://perma.cc/Z7VF-GLVH>.

332. Erin Carson, *Drone Racing Gets Off the Ground*, CNET (Mar. 31, 2017), <https://perma.cc/N8LM-STKE>; *The Drone Racing League*, DRONE RACING LEAGUE, <https://perma.cc/SJ2A-BHSA> (archived Dec. 21, 2019).

333. See Meola, *supra* note 8.

334. Fowler, *supra* note 326.

335. See *infra* Part V.C.

falling from the sky,³³⁶ and the “idiot-resistant” functions mentioned above³³⁷ further prevent human error and increase safety. In combination with common sense and proper precautions, safety concerns regarding recreational drone usage can be substantially mitigated.

IV. RISKS OF DRONE USE

Due to their significant commercial, scientific, public safety, and recreational benefits, drones are here to stay. However, drone-induced concerns have captured the headlines as its technology has become more ubiquitous in the United States.³³⁸ These concerns include public safety risks,³³⁹ invasion of privacy,³⁴⁰ terrorism,³⁴¹ ecosystem disturbance,³⁴² and even illegal drug smuggling.³⁴³

A. Public Safety

As drones are becoming more ubiquitous in the United States, so are drone-related safety concerns. Understandably, no one wants to see a drone collide with an airplane, structure or person. The shared airspace between drones and other aircraft (e.g., helicopters or airplanes) creates legitimate safety concerns.³⁴⁴ However, these safety concerns are largely rooted in hyperbole and distorted statistics rather than concrete evidence.

Although concerns about potential drone-induced collisions capture headlines, these worries are dramatically overblown—the total death count of all drone-caused aerial accidents in the history of the United States was zero as of 2016.³⁴⁵ For a drone to inflict serious damage on a commercial airliner, it would

336. Malek Murison, *5 Technologies Improving Drone Safety*, DRONELIFE (Jan. 23, 2019), <https://perma.cc/V5NF-UBDL>.

337. *Mavic 2*, *supra* note 328.

338. See e.g., Brian Barrett, *When Good Drones Go Bad*, WIRED (Jan. 18, 2016), <https://perma.cc/Q33A-XSLY>.

339. See *infra* Part IV.A.

340. See *infra* Part IV.B.

341. See *infra* Part IV.C.

342. See *infra* Part IV.D.

343. See *infra* Part IV.E.

344. Ashley May, *Drones Can Do Serious Damage to Airplanes, Video Shows*, USA TODAY (Oct. 17, 2019), <https://perma.cc/F9YC-XDSF>.

345. *Id.* But see Adam Lusher, *London Woman Dies in Possibly the First Drone-Related Accidental Death*, THE INDEPENDENT (Aug. 9, 2016), <https://perma.cc/6WLU-QYAL> (finding that a London woman’s death “may be the first fatality linked to [a] non-military” drone in history, but it cannot be confirmed); Skye Gould & Danielle Muoio, *The US Government Is Afraid of One of These Things, and It’s the Wrong One*, BUS. INSIDER (Dec. 18, 2015), <https://perma.cc/GV47-JM89> (finding no drone deaths in the United States as of 2015).

take a “very rare[,] worst case perfect hit.”³⁴⁶ A University of Dayton Research Institute (“UDRI”) engineer nonetheless simulated such a midair collision between a DJI drone and a small airplane, proving that a drone could do more damage to a plane than a bird midflight.³⁴⁷

However, this test created an unrealistic “scenario inconceivable in real life, at a higher speed than the combined maximum speed of the drone and airplane, which is also faster than U.S. Federal Aviation Administration testing . . . guidelines.”³⁴⁸ Since the study’s publication, DJI has demanded the removal of the misleading drone collision video, alleging UDRI “recklessly created and promoted a video that falsely claims to depict a dangerous condition” created by the drone, according to DJI’s Vice President of Policy & Legal Affairs.³⁴⁹

Still, admittedly the possibility exists that a drone could collide with an aircraft, which is why the FAA currently prohibits drones from flying near airports or manned aircraft without an FAA-issued waiver.³⁵⁰ Even with this prohibition, the FAA cites 1800 unauthorized reports of drones flying near other airplanes or airports in 2016.³⁵¹ The first drone collision with a commercial plane happened over Canada—not the United States—in 2017.³⁵² Fortunately, this collision only caused minor damage to the aircraft, and no passenger injuries or deaths.³⁵³ While there have been a handful of small incidents since, no deaths or major injuries have been recorded in the United States.³⁵⁴ In fact, the United States’ first drone-related aircraft crash only happened in 2018.³⁵⁵ However, this drone never even struck the aircraft.³⁵⁶ Instead, the pilot maneuvered the aircraft to avoid the drone

346. May, *supra* note 344.

347. Pamela Gregg, *Risk in the Sky?*, U. DAYTON RES. INST. (Sept. 13, 2018), <https://perma.cc/2W3Z-QKTT>.

348. Press Release, DJI, DJI Demands Withdrawal of Misleading Drone Collision Video (Oct. 19, 2018), <https://perma.cc/P6WE-2THS>.

349. *Id.*

350. *Flying Drones Near Airports (Controlled Airspace)—Part 107*, FED. AVIATION ADMIN. (Dec. 13, 2018), <https://perma.cc/7ECJ-EWPE>; *Recreational Flyers & Modelers Community-Based Organization*, FED. AVIATION ADMIN. (Feb. 18, 2020), <https://perma.cc/E3PA-4G8P>.

351. *Unmanned Aircraft Systems: Innovation, Integration, Successes, and Challenges: Hearing Before the S. Committee on Commerce, Sci., & Transp.*, 115th Cong. (2017) (statement of Earl Lawrence, Director of Unmanned Aircraft Systems, Federal Aviation Administration), <https://perma.cc/RK64-A6SF>; see generally, Alan Boyle, *FAA tests Drone Defense System To Protect Against a Flying Robot Uprising*, GEEKWIRE (Jan. 6, 2017), <https://perma.cc/WH7T-EXMJ> (noting that the FAA has begun testing technologies to detect “unauthorized drone operations near airports and other critical infrastructure” due to an increase of drone sightings by pilots).

352. May, *supra* note 344; Travis Andrews, *A Commercial Airplane Collided with a Drone in Canada, a First in North America*, WASH. POST (Oct. 16, 2017), <https://perma.cc/YRN8-F8AC>.

353. May, *supra* note 344; Andrews, *supra* note 352.

354. May, *supra* note 344; Andrews, *supra* note 352.

355. Alan Levin, *What May Be U.S.’s First Drone-Linked Aircraft Crash Is Being Investigated*, BLOOMBERG (Feb. 15, 2018), <https://perma.cc/9CR3-WG89>.

356. *Id.*

and consequently hit a tree with the tail of the helicopter.³⁵⁷ Again, while the tail of the helicopter was damaged, the pilot and passenger were not injured.³⁵⁸ This occurrence was a rarity, and guarding against such possible mishap isn't worth it given the immense benefits lost. We do not ban or highly restrict any other widely used technology because there is some minimal risk. (We also do not ban birds from existing simply because they sometimes collide with aircraft and have caused high-profile accidents and injuries.)³⁵⁹

This is not to imply that careless drone flights do not trigger general safety concerns.³⁶⁰ Surely, a careless drone operator could crash her drone into the ground, trees, structures, or crowds and cause extensive harm.³⁶¹ Again, however, it is vital to remember that there have been a grand total of zero deaths caused by drone-related accidents in the United States.³⁶² The drone collisions that do commonly occur are generally harmless,³⁶³ and only cause psychological fear, if anything.³⁶⁴ For example, a recreational drone crashed into a tree on the South Lawn of the White House in 2015, which caused a temporary lockdown.³⁶⁵ Additionally, a drone crashed into Seattle's Space Needle in 2016, but there were no injuries or property damage.³⁶⁶

Moreover, drone collisions that do result in injury are almost always minor—not life-threatening. For example, a drone crashed into the stands during the Great Bull Run at the Virginia Motorsports Park and injured a few individuals.³⁶⁷

357. *Id.*

358. *Id.*

359. See e.g., Gregory Korte, *Bird Strikes by Airplanes Tied Record in 2018, FAA Data Shows*, USA TODAY (Feb. 6, 2019), <https://perma.cc/5X4S-PG33>; *Plane Collisions with Birds Caused More than \$600,000 in Damage at Salt Lake Airport*, USA TODAY (Mar. 2, 2019), <https://perma.cc/ERJ8-DCFV>; Sarah Zielinski, *The Perils of Bird-Plane Collisions*, SMITHSONIAN (Jan. 6, 2009), <https://perma.cc/WE67-8TSJ>; see also Thom Patterson, *Preventing Another "Miracle on the Hudson" Emergency*, CNN TRAVEL (Jan. 13, 2019), <https://perma.cc/GMH9-VYXZ> (noting that, in 2009, two 8-pound geese flew into each of a plane's twin engines, which prompted an emergency landing—the most famous emergency landing known as the "Miracle on the Hudson").

360. ARTHUR HOLLAND MICHEL & DAN GETTINGER, DRONE INCIDENTS: A SURVEY OF LEGAL CASES 6.

361. DOUGLAS J. WOOD ET AL., REED SMITH, CROWDED SKIES: OPPORTUNITIES AND CHALLENGES IN AN ERA OF DRONES 47-50 (2015), <https://perma.cc/5VMY-NBGF>.

362. *Cf.* Lusher, *supra* note 345.

363. Miriam McNabb, *Diving into the FAA Administrator's Fact Book: Why "Drone Incidents" are Concerning for Regulators*, DRONELIFE (Aug. 19, 2019), <https://perma.cc/V985-PT89> (noting the low rate of accidents and no fatalities in the United States from 2006 to 2015).

364. Jelani Cobb, *What Our Paranoia About Drones Says About Us*, N.Y. TIMES (Feb. 12, 2015), <https://perma.cc/5NLP-SXYQ>.

365. 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://perma.cc/UG84-4HPC>.

366. Stephanie Mlot, *VIDEO: Drone Crashes into Seattle's Space Needle*, PCMAG (Jan. 13, 2017), <https://perma.cc/J53B-Q92B>.

367. Martin Weil, *Drone Crashes into Virginia Bull Run Crowd*, WASH. POST (Aug. 26, 2013), <https://perma.cc/BH5M-8823>.

Luckily, those who were injured by the drone only experienced “very minor injuries” and were not taken to a hospital.³⁶⁸ Additionally, wedding guests sued the groom and an event-planning company at a wedding for negligence when the guests suffered head injuries allegedly caused by a drone flown by the groom.³⁶⁹ However, personal injuries caused by drone crashes are incredibly rare.³⁷⁰ More commonly, drone crashes cause minor property damage and even in those cases, operators can already be charged with misdemeanors or fines under existing laws.³⁷¹ While safety concerns are understandable, drone companies are cognizant of these risks, and thus, are continuing to develop enhanced safety features that maximize their utility while minimizing any risks.³⁷²

B. Privacy Concerns

The possibility of unwarranted drone surveillance has also sparked strong fears of privacy violations among the American public, and in particular the ACLU.³⁷³ Unsurprisingly, the general consensus is that Americans do not wish to be “watched” by drones.³⁷⁴ However, drones are not the primary vehicle that drives these concerns. Rather, the public is primarily concerned that a drone will malfunction and cause damage rather than with intentional misuse by pilots (e.g., drones “might not be used in a way that respects my privacy”).³⁷⁵

368. *Id.*

369. Kirk Enstrom, *Women Sue Groom Over Drone Injuries at Wedding Reception*, WMUR (Dec. 8, 2016), <https://perma.cc/664A-ANL8>.

370. ARTHUR HOLLAND MICHEL & DAN GETTINGER, CTR. STUDY DRONE AT BARNARD C., DRONE INCIDENTS: A SURVEY OF LEGAL CASES 3-4 (2017), <https://perma.cc/4U2E-ADWR>.

371. *Id.*

In March 2016, a New York City man was charged with disorderly conduct after he accidentally crashed a drone into the Empire State Building. The individual, who pleaded guilty, was given community service and a \$200 fine. In a similar case in October 2016, a drone crashed in Midtown Manhattan and the 22-year-old operator was charged with reckless endangerment and unlawful operation of a drone. In January 2017, a 24-year-old man was arrested and charged with criminal mischief after crashing a drone through a window on the 27th floor of a residential building on the East River, also in Manhattan.

Id.

372. *See generally, supra* Part III.J (noting that drones are equipped with many safety functions); Murison, *supra* note 336.

373. STANLEY & CRUMP, *supra* note 297; *see also* DRONES: *Eyes in the Sky*, ELECTRONIC PRIVACY INFO. CTR. (Oct. 2014), <https://perma.cc/QG7U-2CF8>; *see also* M. Ryan Calo, *The Drone as Privacy Catalyst*, 64 STAN. L. REV. ONLINE 29 (2011).

374. Stephen Rice, *Eyes in the Sky: The Public Has Privacy Concerns About Drones*, FORBES (Feb. 4, 2019), <https://perma.cc/2WHQ-ZYUQ>; Calo, *supra* note 373.

375. OFF. INSPECTOR GEN., U.S. POSTAL SERV., PUBLIC PERCEPTION OF DRONE DELIVERY IN THE UNITED STATES 8 (2016), <https://perma.cc/MW6M-AG4S>. While this study is reported within the drone delivery context, the United States Postal Service found that only 14% of Americans are worried about intentional misuse. *Id.* Whereas 46% of Americans are actually worried about drone malfunction. *Id.*

Additionally, public sentiments surrounding drone use and privacy varied among participants in a study conducted by Embry-Riddle Aeronautical University.³⁷⁶ These studies surveyed participants on their *perception and attitudes* towards drones, not on whether participants had actually been subjected to surveillance (because almost certainly they have not).³⁷⁷ Participants' support for or opposition to drones depended on where they lived and on their political affiliation, gender, and ethnicity, among other factors.³⁷⁸

Drone-related privacy concerns and fears of mass governmental surveillance also spark conversations about their legal limits.³⁷⁹ Currently, the FAA does not have any regulations that specifically address drone flights over residential areas, according to Ryan Wallace, assistant professor of Aeronautical Science at Embry-Riddle Aeronautical University.³⁸⁰ Theoretically, a drone flying over a residential area does not violate federal laws if its operator complies with current FAA regulations, such as visual line of sight, registration, and altitude limitations.³⁸¹ Unregulated drones "could" hypothetically violate personal privacy by peering into houses or apartments.³⁸² However, many states have already implemented their own privacy laws prohibiting unwarranted drone surveillance.³⁸³

C. Terrorism

The threat that drone technology could be used as a means for terrorism has also raised alarm. As mentioned, the most prominent incident to surface these concerns occurred in 2015, when a drone crashed on the White House lawn.³⁸⁴ A

376. Rice, *supra* note 374; see also Paul Hitlin, *8% of Americans Say They Own a Drone, While More Than Half Have Seen One in Operation*, PEW RES. CTR. (Dec. 19, 2017), <https://perma.cc/W8LM-4SE5>.

377. Rice, *supra* note 374; Hitlin, *supra* note 376.

378. Rice, *supra* note 374; Hitlin, *supra* note 376 ("For instance, 25% of 18- to 29-year-olds say they would feel indifferent if they saw a drone flying near their home, but that share falls to just 6% among those 65 and older. By the same token, just 5% of young adults—but 17% of those 65 and older—say they would feel angry in this situation. Older Americans are also much more likely to think that drone use by private citizens should be banned in certain areas—most notably, near people's homes (73% of older adults think this should not be allowed) or at events such as concerts or rallies (67%).").

379. *Id.*; ELECTRONIC PRIV. INFO. CTR., *supra* note 373; Calo, *supra* note 373.

380. Rice, *supra* note 374.

381. *Id.*

382. ELECTRONIC PRIV. INFO. CTR., *supra* note 373.

383. *Id.*

384. Schmidt & Shear, *supra* note 365.

government employee was allegedly flying it near the White House for recreational purposes, when he lost control of it.³⁸⁵ Though this incident did not endanger anyone,³⁸⁶ it raised legitimate concerns about the potential for drones to be used for terrorism.

Just a few days earlier, the U.S. military, Department of Homeland Security and the FAA held a summit in Arlington, Virginia, regarding this very threat.³⁸⁷ The summit featured shocking videos of “low-cost drones firing semi-automatic weapons,” and warned that “Syrian rebels are importing consumer-grade drones to launch attacks.”³⁸⁸ The conference also featured models of popular consumer drones rigged to carry explosives, including a DJI Phantom 2, a newer model that crashed over the White House.³⁸⁹

Security concerns arising from this aerial technology are understandable but need to be considered in proper context. As with many other novel innovations, drones offer a new way for people with malevolent intentions to carry out destructive actions, just like guns do. U.S. officials have been painfully aware of this threat for some time.³⁹⁰ Nevertheless, William Hewitt, the chief of the UAS Threat Integration Cell at the U.S. Department of Homeland Security, believes that this threat, which used to be primarily theoretical, is now very real.³⁹¹ The FAA’s response to these concerns has been clear: dramatically ratchet up safety regulation in the past decade.³⁹²

The logic of increasing drone regulation in order to reduce the risk of terrorism, however, is deeply flawed. People who intentionally seek to commit horrific acts will not be deterred in the least by FAA action—its regulations affect only law-abiding individuals and firms, who are not likely to be the ones flying drones with explosives into sensitive government buildings. By intentionally exaggerating and scaring the public regarding the malevolent potential of drones, we have ironically created our own self-induced form of terrorism that the FAA regulations are wholly ineffective at preventing.

385. Michael D. Shear & Michael S. Schmidt, *White House Drone Crash Described as a U.S. Worker’s Drunken Lark*, N.Y. TIMES (Jan. 27, 2015), <https://perma.cc/D6H7-LFL9>.

386. See Zeke J. Miller, *Drone That Crashed at White House Was Quadcopter*, TIME (Jan. 26, 2015), <https://perma.cc/XAH2-ZYSU>.

387. Kevin Poulsen, *Why the US Government Is Terrified of Hobbyist Drones*, WIRED (Feb. 5, 2015), <https://perma.cc/6DHQ-K2UX>.

388. *Id.*

389. *Id.*

390. See *Taylor*, 856 F.3d at 1091 (“As unmanned aircraft technology has advanced, small unmanned aircraft have become increasingly popular. In response, the FAA has taken a more active regulatory role.”).

391. See Levin, *supra* note 355.

392. See, e.g., Tiffany Gruenberg, *Safety Concerns Prompt New FAA Regulations for Drones*, LEXOLOGY (Apr. 18, 2019), <https://perma.cc/X6E9-M2E8>; see also *Taylor*, 856 F.3d 1089.

D. Ecosystem Risks: Drones Disturb Wildlife and Detract from Nature

Due to the immense benefits drones can offer researchers and conservationists, the proliferation of drones will likely continue in these areas. However, the proliferation of drone usage triggers other concerns over potential wildlife disturbance and distractions (i.e., nuisance).³⁹³

While drone-induced disturbances to wildlife present a plausible concern, researchers are “still learning” about whether and how drones actually disrupt wildlife.³⁹⁴ More research is required because different species in different environments elicit different reactions to drones.³⁹⁵ The variations may depend on the animal, and on the drone’s size, speed, and approach angle.³⁹⁶ For instance, semi-captive wild birds only reacted towards a drone’s approach angle, according to a study conducted by a team of French and South African biologists.³⁹⁷ Interestingly, a drone’s color, speed, and quantity of flights had “no measurable impact” on the birds’ behaviors.³⁹⁸ Similarly, Adélie penguins reacted only towards a drone’s angle of approach and flying altitude in a study commissioned by the German Federal Environment Agency.³⁹⁹ By accounting for this, researchers can quickly modify behavior to reduce negative externalities on animal populations.

While these studies show only one dimension of animal behavior (i.e., physical response), others suggest that drones may also impact an animal’s physiology.⁴⁰⁰ For example, drones flown near black bears increased bears’ stress levels and heartrate, according to Mark Ditmer of the Department of Fisheries, Wildlife & Conservation Biology at the University of Minnesota.⁴⁰¹ Ditmer argued that these bears were negatively affected by drones even though they did not show any behavioral responses.⁴⁰² With more research that quantifies animal disturbance, case-by-case guidelines on different species of animals are being developed to “mitigate or alleviate the potential [drone] disturbance to wildlife.”⁴⁰³

393. See Hodgson et al., *supra* note 264.

394. See *id.*

395. *Id.*; Jarrod Hodgson & Lian Pin Koh, *A Guide to Using Drones To Study Wildlife: First, Do No Harm*, THE CONVERSATION (May 23, 2016), <https://perma.cc/YH77-ETDH>.

396. Marie-Charlott Rümmler et al., *Measuring the Influence of Unmanned Aerial Vehicles on Adélie Penguins*, 39 POLAR BIOLOGY 1329 (2016); Hodgson & Koh, *supra* note 395.

397. Elisabeth Vas et al., *Approaching Birds with Drones: First Experiments and Ethical Guidelines*, 11 BIOLOGY LETTERS 20140754 (2015).

398. *Id.*

399. See generally Rümmler et al., *supra* note 399 at 39.

400. See generally Mark A. Ditmer et al., *Bears Show a Physiological but Limited Behavioral Response to Unmanned Aerial Vehicles*, 25 CURRENT BIOLOGY 2278 (2015).

401. *Id.*

402. *Id.*

403. Hodgson & Koh, *supra* note 395.

Still other environmental concerns focus on how drones can become a distraction to national park visitors and have raised concerns for the safety of national park rangers.⁴⁰⁴ Recently, a drone operator lost control of her drone and crashed it at the Grand Canyon National Park; national park volunteers witnessed a drone disturbing a herd of bighorn sheep at Zion National Park; and a drone flew around a crowded amphitheater and over the iconic sculptures at Mount Rushmore National Memorial.⁴⁰⁵ A drone also crashed into geysers at Yellowstone National Park, which required park officials to fish the drone and its equipment out of the hot spring.⁴⁰⁶

In response to these claims, the U.S. National Park Service prohibited the use of drones within units of the National Park System in 2014.⁴⁰⁷ This prohibition is aimed at preventing potential drone-related “impacts such as harming visitors, interfering with rescue operations, causing excessive noise, impacting [views] and disturbing wildlife.”⁴⁰⁸ The Park Service did acknowledge in its Policy Memorandum, however, that drone use “remains relatively infrequent across the National Park System.”⁴⁰⁹ Further, this drone prohibition was initially enacted as an interim measure until a “determination has been made in the professional judgment of the [park] superintendent that it will not result in unacceptable impacts on park resources and values.”⁴¹⁰ As a result, drone operators must obtain a special use permit to fly their drone of any size in national parks, including for recreational and commercial purposes.⁴¹¹

E. Drug Smuggling

Another concern that has been raised regarding the growing availability of commercial drones is their potential use for illegal smuggling operations.⁴¹² Because of their small size and ability to fly in a wide range of environments, drones are highly versatile tools for transporting small goods short distances. Of course, this is the concept that many high-tech companies like Amazon.com seek to take

404. *Unmanned Aircraft in the National Parks*, U.S. NAT'L PARK SERV., <https://perma.cc/JQ6C-CQLL> (archived Jan. 5, 2020).

405. Policy Memorandum from Jonathan B. Jarvis, Director, National Park Service, on Unmanned Aircraft (Jun. 19, 2014), <https://perma.cc/5WSX-UMPX>.

406. *Unmanned Aircraft in the National Parks*, *supra* note 404; Christine Bednarz, *6 Accidents That Actually Happened in National Parks*, NAT'L GEOGRAPHIC (Apr. 20, 2018), <https://perma.cc/4W7Z-XE5Q>.

407. Policy Memorandum from Jonathan B. Jarvis, *supra* note 405.

408. *Id.*

409. *Id.*

410. *Id.*

411. *Unmanned Aircraft in the National Parks*, *supra* note 404; Policy Memorandum from Jonathan B. Jarvis, *supra* note 405.

412. Frank Wolfe, *U.S. DEA: Border Wall or No, Drone Drug Smuggling Likely To Increase*, ROTOR & WING INT'L (Jan. 10, 2019), <https://perma.cc/CPR3-2G8T>.

advantage of when proposing drone use for package delivery.⁴¹³ But, the same feature has also led to a small number of cases of people abusing drones for illegal smuggling purposes.

The most prominent examples are of drones being utilized to sneak contraband into American and English prisons.⁴¹⁴ In 2015, a drone dropped a package containing tobacco, marijuana and heroin into an Ohio prison yard.⁴¹⁵ Seventy-five inmates gathered around the package and a fight ensued, requiring prison guards to deploy pepper spray. A similar incident occurred in London, when a drone attempted to deliver contraband items, including drugs and cell phones, directly to an inmate's window.⁴¹⁶ That attempt was caught on camera and guards were able to confiscate the package contents. Statistically, it is difficult to know exactly how often incidents like this occur, but anecdotally they seem rare. Nevertheless, as the technology has become so inexpensive and easy to use, it would be hardly surprising if we witnessed an uptick in drones being employed with illicit smuggling intent.

V. RESPONSIBLE POLICY AND REGULATORY REFORMS

To address the concerns detailed above,⁴¹⁷ the FAA implemented significant drone regulations—notably the line-of-sight and registration requirements (see *supra* Part II.B). In practice, however, these two regulations utterly fail to remedy safety or privacy concerns. Instead, the FAA's line-of-sight and drone registration requirements work primarily to suffocate innovation in drone technology and reduce the social utility of drone usage.

A. *Eliminate the Line-of-Sight Regulation—It Stifles Innovation Without Any Accompanying Benefit*

Drones are on the cusp of revolutionizing the world with immediate commercial, public safety, and research applications. However, their apparently limitless potential is seriously hampered by the FAA's line-of-sight regulation, which mandates that drone operators keep their drones within their own eyesight.⁴¹⁸ The intent of the line-of-sight rule was to increase public safety and reduce collisions by requiring operators to see their drones directly—thus putting them in a

413. See, e.g., Jillian D'Onfro, *Amazon's New Delivery Drone Will Start Shipping Packages "in a Matter of Months,"* FORBES (June 5, 2019), <https://perma.cc/WM7D-DW6F>.

414. *Prisons Work To Keep Out Drug-Smuggling Drones*, NPR (Nov. 15, 2017), <https://perma.cc/VS9C-UUY6>; *Drone Delivers Drugs & Mobiles to London Prisoners*, BBC NEWS (May 16, 2016), <https://perma.cc/WS2M-A7DY>.

415. Lorenzo Ferrigno, *Ohio Prison Yard Free-For-All After Drone Drops Drugs*, CNN (Aug. 5, 2015), <https://perma.cc/SX4G-NGQ9>.

416. *Drone Delivers Drugs & Mobiles to London Prisoners*, *supra* note 414.

417. See *supra* Part IV.

418. 14 C.F.R. § 107.31.

better position to avoid imminent hazards.⁴¹⁹ While this argument has superficial appeal, further scrutiny renders it absurd. Today's drone operators can just as easily (and perhaps even more easily if one considers military drones) prevent collisions by utilizing first-person camera technology.⁴²⁰ More critically, this FAA regulation disincentivizes American companies, like Amazon and Google, from investing aggressively in burgeoning drone technology due to fear of regulatory obstacles making their visions too burdensome to achieve.⁴²¹

1. *What Is the Point of the Line-of-Sight Regulation?*

To ensure that drone operators can safely see and avoid aircraft, people, property, and other hazards, the FAA requires drones to fly within the visual line of sight of its operator “unaided by any device other than corrective lenses.”⁴²² This “see-and-avoid requirement” is at the heart of the FAA’s regulatory structure, ostensibly mitigating the risk of aircraft colliding in midair.⁴²³ For example, a manned aircraft’s pilot can look outside from inside the cockpit to see whether other planes are on a collision course with her vessel.⁴²⁴ Conversely, the FAA argues that “a person on the ground cannot see and avoid other aircraft in the same manner as a pilot who is inside a manned aircraft.”⁴²⁵ While superficially accurate, the FAA seems almost oblivious to the fact that drone operators do not need to visually see their drones to avoid collision. Drones have built-in cameras and collision-avoidance technology, which is often far superior to human eyesight and reflexes.

Manufacturers today are more than capable of installing high resolution cameras into drone cockpits, which transmit a live, “first person view” feed to their operator,⁴²⁶ as Figure 2 below shows. A drone’s remote controller either has a built-in screen or allows a smartphone to plug into the controller to act as a screen.⁴²⁷ While flying, drone operators can see exactly what their drone sees through this screen and thus provide an accurate and effective method for operators to see and avoid obstacles even when they are miles away.⁴²⁸ More critically,

419. See *infra* Part V.A.1 (discussing the purpose behind the FAA’s line-of-sight regulations).

420. See generally Fintan Corrigan, *How Do Drones Work and What Is Drone Technology*, DRONEZON (Oct. 30, 2019), <https://perma.cc/G483-HJBZ> [hereinafter Corrigan, *How Do Drones Work*].

421. See *Amazon Says It May Take Drone Testing Outside U.S.*, *supra* note 4.

422. Operation and Certification of Small Unmanned Aircraft Systems, 81 Fed. Reg. 42,063 (June 28, 2016) (to be codified at scattered sections of 14 C.F.R.).

423. *Id.* at 42,074.

424. *Id.* at 42,092

425. *Id.* at 42,093

426. Corrigan, *How Do Drones Work*, *supra* note 420.

427. *Id.*

428. *Id.*

drones now have the technological ability to autonomously detect and avoid objects from all angles.⁴²⁹ Thus, the FAA's "line of sight" regulation does not serve its avowed purpose—drone operators have other, more effective means of identifying and avoiding hazards without requiring direct visual eye contact at all times.



FIGURE 2.

The top picture shows what a drone operator sees when operating their drone. The bottom picture shows a deployed drone in the sky from a drone operator's visual eyesight.⁴³⁰ Drone operation through a live camera feed provides drone operators with a clearer visual of their drones to better see and avoid obstacles in a drone's path. As depicted by the bottom picture, drone operators may have a more difficult time avoiding obstacles with just their eyesight.

429. Fintan Corrigan, *12 Top Collision Avoidance Drones and Obstacle Detection Explained*, DRONEZON (Oct. 28, 2019), <https://perma.cc/6VU7-R58S>.

430. Drew Bennett, *Sky Viper Quadcopter Drone and Camera Drone Review*, BENSPARK FAMILY ADVENTURES (Nov. 25, 2014), <https://perma.cc/8BT4-GBNV>; *Autel Evo Drone Controller Screen*, YOUTUBE (June 30, 2018), <https://perma.cc/M7KY-QLRB>.

Not surprisingly, the line of sight's "see and avoid" philosophy has drawn sharp criticism from media and industry commentators alike, including the News Media Coalition, the National Association of Mutual Insurance Companies (NAMIC), and Drone Labs.⁴³¹ These critics reasonably point out that the use of FPV technology has advanced to the point where pilots can use it to meet or exceed the visual line of sight's see and avoid requirement.⁴³² United Parcel Service agrees with this position, noting that FPV technology has been safely and effectively used in the drone hobbyist community for many years now.⁴³³ In fact, many pilots feel that the FPV view is superior and safer than their own limited eyesight from the ground.⁴³⁴

In addition to failing the FAA's own see and avoid logic, the line-of-sight regulation also fails to address other public safety concerns (e.g., potential drone collisions with a manned aircraft). As detailed above in Part IV.A, there have been zero injuries or deaths in the history of the United States from collisions between drones and other manned aircraft.⁴³⁵ Attributing this statistic to the effectiveness of the FAA's line-of-sight rule is absurd, as at most one person in the history of the world has died from accidental drone injury.⁴³⁶ When compared to other public safety threats, the risk presented by drones is dramatically overstated. Comparatively speaking, cars kill over 40,000 Americans annually,⁴³⁷ firearms kill 30,000,⁴³⁸ and drug overdoses claim 70,000 lives each year.⁴³⁹ Rather than applauding the dubious effectiveness of the line-of-sight regulation, regulatory agencies would be far better served focusing their attention on activities that actually kill Americans.

So why do we have this line-of-sight regulation, given its doubtful efficacy? It is based on systematic risk-misperception, exaggerating fear over reality. The National Academies of Sciences, Engineering, and Medicine criticized the FAA in its FAA-commissioned report by pointing out that the agency now has "a culture with a near-zero tolerance for risk," and fails to account for "the various ways in

431. Operation and Certification of Small Unmanned Aircraft Systems, 81 Fed. Reg. at 42,093.

432. *Id.*

433. *Id.*

434. See generally James Trew, *First-Person-View Drone Flying Is the Closest Thing to Being a Bird*, ENGADGET (July 25, 2016), <https://perma.cc/9ZFU-N4EZ>; Alan Pearlman, *Everything You Need To Know About FPV Flying*, UAV Coach (Aug. 20, 2016), <https://perma.cc/A7SS-FVMD>.

435. McNabb, *supra* note 363; Lusher, *supra* note 345.

436. *Id.*

437. Nathan Bomey, *U.S. Vehicle Deaths Topped 40,000 in 2017, National Safety Council Estimates*, USA TODAY (Feb. 15, 2018), <https://perma.cc/4N44-RXFM>.

438. Sarah Mervosh, *Nearly 40,000 People Died From Guns in U.S. Last Year, Highest in 50 Years*, N.Y. TIMES (Dec. 18, 2018), <https://perma.cc/H59P-SLHT>.

439. *Overdose Death Rates*, NAT'L INST. ON DRUG ABUSE (Jan. 2019), <https://perma.cc/WEM3-WZ96>.

which technology may reduce risk and save lives.”⁴⁴⁰ The Committee concluded that “fear of making a mistake drives a risk culture” at the FAA, particularly with respect to drones.⁴⁴¹ In many ways, the FAA fails to take a holistic approach for drone risk assessment, and in response has implemented an imbalanced regulation in its line-of-sight rule. By flying beyond one’s line of sight, drones would be capable of preventing derailments, inspecting cell phone towers, delivering medical devices to patients in cardiac distress, and assisting firefighters.⁴⁴² The FAA’s line-of-sight rule prevents a multitude of public safety and commercial applications, while doing little to reduce accidents.⁴⁴³ In sum, the FAA’s line-of-sight restriction represents a classic, overly conservative approach to risk regulation—it focuses far too narrowly on the new, small risks that drones pose instead of on their potential ability to save lives if they are allowed to fly far distances beyond the line of sight of their operator.⁴⁴⁴

2. *The Benefits of Beyond the Visual Line of Sight (BVLOS)*

As mentioned above, the current FAA regulatory scheme prevents drones from operating beyond the operator’s visual line of sight (BVLOS), unless an operator obtains a “special, hard-to-get waiver” from the FAA.⁴⁴⁵ In fact, 99% of the first 1200 BVLOS applicants have failed to receive approval.⁴⁴⁶ Effectively, the FAA is hampering “the next big opportunity” for commercial drone operators since many applications are impossible to execute without BVLOS.⁴⁴⁷ Thus, unlocking the full potential of commercial drones require regulators to allow drones to fly BVLOS.⁴⁴⁸

By flying beyond the visual line of sight, drones allow businesses to replace traditional, more expensive methods such as helicopters and satellites. As a result, businesses reap three key benefits from drones: improved (1) safety, (2) accuracy, and (3) efficiency.⁴⁴⁹

Specific to efficiency, commercial businesses that utilize BVLOS drone operations can significantly reduce expenses and maximize their investment in drone

440. NAT’L ACADS. SCI. COMMITTEE ON ASSESSING RISKS OF UNMANNED AIRCRAFT SYS., INTEGRATION ENGINEERING, & MED., ASSESSING THE RISKS OF INTEGRATING UNMANNED AIRCRAFT SYSTEMS (UAS) INTO THE NATIONAL AIRSPACE SYSTEM 1-2 (2018).

441. *Id.* at 2.

442. *Id.* at 1.

443. Marcontell & Douglas, *supra* note 19.

444. *Id.*; NAT’L ACADS. SCI. COMMITTEE ON ASSESSING RISKS OF UNMANNED AIRCRAFT SYS., *supra* note 440.

445. FERGUSON, *supra* note 24 at 1.

446. *Id.*

447. *Id.*

448. *Id.*

449. *Id.* at 3.

technologies.⁴⁵⁰ For instance, a company that inspects “10,000 miles of power lines a year would save \$1.7 million in the first year of operation,” a savings that could amount to \$9 million over five years.⁴⁵¹ Based on a case study provided by Precision Hawk, electric utility companies, for example, can either use a manned helicopter or drones to inspect power lines.⁴⁵² With a manned helicopter, the costs ranges from \$40-\$700 per mile; whereas, with a BVLOS drone, the cost ranges from \$10-\$25 per mile of inspection.⁴⁵³ Accordingly, that utility company can save up to \$1.7 million per year by using drones.⁴⁵⁴ These potential savings could be applied to many more businesses across various industries. Thus, BVLOS drone operations allow companies to save money so they can reinvest, innovate, and create more jobs.

3. *Innovation, Jobs, and an Economic Boost Are Waiting for More Accommodating Regulations*

Without regulatory flexibility from the FAA, major American companies (e.g., Google and Amazon) are investing in drone technology outside the United States’ borders. Unfortunately, this lost opportunity means that foreign nations—instead of America—are benefiting from technological advancements, new jobs, and an economic upswing. The United States cannot reap these benefits until the FAA removes its line-of-sight regulation.

For example, major U.S. companies are now testing drone package deliveries in more regulatory-accommodating countries.⁴⁵⁵ In Australia, Google X’s “Project Wing” successfully delivered burritos and medication to customers with drones.⁴⁵⁶ Through extensive testing, Google overcame hurdles to perfect drone delivery by extending drone battery life for long distance deliveries, learning how to package perishable products, and perfecting delivery coordinates for precise deliveries.⁴⁵⁷ Similarly, in Canada, Amazon tested drone deliveries after the e-commerce giant’s frustration with the FAA’s line-of-sight regulation inside the United States.⁴⁵⁸ With the “full blessing of the Canadian government,” Amazon

450. *Id.*

451. FERGUSON, *supra* note 24 at 3.

452. *Id.*

453. *Id.*

454. *Id.*

455. *The Future of Drones Depends on Regulation, Not Just Technology*, THE ECONOMIST (Jun. 8, 2017), <https://perma.cc/W6NR-CGEN> [hereinafter *Future of Drones*].

456. Alex Hern, *Alphabet Tests Project Wing Drones by Delivering Burritos and Medicine*, THE GUARDIAN (Oct. 17, 2017), <https://perma.cc/CR3A-3C53>.

457. *Id.*

458. Ed Pilkington, *Amazon Tests Delivery Drones at Secret Canada Site After U.S. Frustration*, THE GUARDIAN (Mar. 30, 2015), <https://perma.cc/MCC7-ARK5>.

experimented with hybrid drones that took off and landed vertically and horizontally, and successfully delivered packages over long distances.⁴⁵⁹

To the FAA's credit, however, the agency did eventually allow some drones to operate in the United States beyond the visual line-of-sight through the agency's "Part 107" exception.⁴⁶⁰ As it stands, the FAA requires most drone pilots to obtain waivers to fly BVLOS.⁴⁶¹ However, obtaining this waiver is "cumbersome [because of stringent requirements] and can take three to six months, which is longer than most innovative companies can afford to wait."⁴⁶² Further, operating drones BVLOS is not realistic using the waiver process alone because only 16% of the 11,325 applications that have been reviewed have been approved in 2018.⁴⁶³

While the FAA's Part 107 attempts to allow some drones to fly BVLOS is a small step in the right direction, the agency needs to move much more quickly. Businesses like Amazon desperately want to invest greater resources into drone technology but are deterred from doing so because of unaccommodating drone regulations. Paul Misener, Amazon's Vice President of Global Public Policy, criticized the FAA and its lengthy waiver process at a Subcommittee on Aviation, Operations, Safety, and Security meeting in Washington, D.C. last year. Misener acknowledged that the "United States is catching up" but emphasized that the United States "remains behind in planning for future commercial [drone] operations."⁴⁶⁴ Frustrated by the FAA's lengthy waiver approval process, Amazon also took matters into its own hands years ago to satisfy its innovative appetite. Amazon applied to begin testing drone deliveries in the United States in 2014 but did not receive a waiver from the FAA until almost a year later.⁴⁶⁵ By that time, the drone that Amazon had requested permission to fly had become obsolete and the company "moved onto more advanced designs that were being tested abroad."⁴⁶⁶ The FAA seemingly ignored Amazon's request, and in response, Amazon built a new research and development center in the United Kingdom and began testing drone operations there.⁴⁶⁷ Amazon received approval from the U.K. Civil Aviation Authority to conduct testing—allowing Amazon to operate drones beyond the line-

459. *Id.*

460. Ed Oswald, *Here's Everything You Need To Know About Amazon's Drone Delivery Project, Prime Air*, DIGITAL TRENDS (May 3, 2017), <https://perma.cc/PGT7-84MV>.

461. *Part 107 Waivers*, *supra* note 150.

462. Jennifer van Grove, *Report: FAA Stifling Commercial Drone Use*, SAN DIEGO UNION TRIB. (Jun. 11, 2018), <https://perma.cc/3K9M-626Q>.

463. Nick Zazulia, *Getting Beyond the FAA's Part 107 BVLOS Waiver Application*, AVIONICS (Aug. 27, 2018), <https://perma.cc/BYL7-7MHE>.

464. Ryan Mac, *Amazon Hammers FAA For Lack Of "Impetus" Over Drone Policy*, FORBES (Mar. 24, 2015), <https://perma.cc/4DMS-MECQ>.

465. Jack Nicas, *Amazon Asks FAA for Permission To Fly Drones*, WALL ST. J. (Jul. 11, 2014), <https://perma.cc/XH6T-3YHE>.

466. Jay Greene, *Amazon Says FAA-Approved Drone Is Already Obsolete*, SEATTLE TIMES (Mar. 24, 2015), <https://perma.cc/9KTG-36F5>.

467. *Id.*

of-sight—and delivered its first package by drone on December 7, 2016 in the United Kingdom.⁴⁶⁸ While the FAA intended to do good by instituting its Part 107 BVLOS waiver process, this is a prime example of how the agency’s tortoise-like pace is stifling innovation and investment inside the United States.

Other countries have also taken advantage of American regulatory delays in expanding BVLOS flying. A *Fortune* article headlined, *Oh! Canada May Beat U.S. to Commercial Drone Delivery*, detailed how Drone Delivery Canada (“DDC”) efficiently worked with Canadian regulators and community stakeholders to successfully deliver mail, food, medical supplies, and general goods to the Moose Cree community in Northern Canada.⁴⁶⁹ DDC worked collaboratively with researchers from the Universities of Toronto and Waterloo on fully autonomous flights that went dozens of miles beyond the line of sight of drone operators.⁴⁷⁰ Other countries, like Japan, are now acting quickly to remove their version of the FAA’s visual line-of-sight rule in order to spur innovation and avoid a lengthy waiver process like we have.⁴⁷¹ Instead, the Japanese government will require drones to be equipped with cameras and sensors and fly below 150 meters, and drone operators must have a history of safe flights.⁴⁷² Similarly, the United Kingdom actively working to remove its line-of-sight regulation.⁴⁷³ In response to “the increasing popularity of commercial drone operations,” the urgency to remove this requirement is essential to “help make [drone deliveries] happen” safely, according to David Harrison of the U.K. National Air Traffic Control Service.⁴⁷⁴ Canada, Japan and the United Kingdom are understandably taking a more aggressive approach to integrating drones into their airspace than the United States because these countries appreciate the tremendous economic and innovative impact of drones. They see an opportunity to capture a market that the FAA is complicit in crippling inside the United States.

In sum, the United States must join its foreign counterparts in allowing entrepreneurial businesses to realize the benefits of drone technology. Sadly, the FAA

468. Elizabeth Weise, *Amazon Delivered Its First Customer Package by Drone*, USA TODAY (Dec. 14, 2016), <https://perma.cc/7JZK-9GR7>.

469. Barb Darrow, *Oh! Canada May Beat U.S. to Commercial Drone Delivery*, FORTUNE (Oct. 9, 2017), <https://perma.cc/V9NH-WHE5>; Press Release, Drone Delivery Canada, Moose Cree First Nation and Drone Delivery Canada Launch Remote Community Drone Delivery Commercialization in Northern Canada (Oct. 4, 2017), <https://perma.cc/DH8N-77H4>.

470. Darrow, *supra* note 469.

471. Marco Margaritoff, *Japan To End Beyond Visual Line-of-Sight Regulations by End of 2018*, THE DRIVE (Mar. 30, 2018), <https://perma.cc/4ZVG-FCAF>.

472. *Id.*

473. *Setting the Path to Drone Deliveries and Remote Inspections: Making Beyond Visual Line of Sight Drone Operations Commonplace*, CIV. AVIATION AUTHORITY (Dec. 9, 2019), <https://perma.cc/FZE8-TMW6>; Graeme Paton, *Drone Deliveries on Course for Next Year*, THE TIMES (Mar. 6, 2018), <https://perma.cc/MU7X-9GCG>.

474. Haye Kesteloo, *Drone Deliveries May Become a Reality in the UK by 2019*, DRONEDJ (Mar. 6, 2018), <https://perma.cc/PPE2-X6MB>.

lacks the impetus to develop timely policies that incentivize innovation.⁴⁷⁵ Although the FAA has slowly moved towards loosening its line-of-sight regulation in the United States, the agency's actions belie a larger point: its culture of "near-zero tolerance for risk" has stifled innovation and needs to be uprooted immediately.⁴⁷⁶

4. *The FAA's Drone Integration Pilot Program (IPP): A Step in the Right Direction*

Despite the above critique, the United States is slowly moving in the right direction. With the recent creation of the Drone Integration Pilot Program ("IPP"), the Trump administration took a small step towards allowing flight beyond the line of sight in 2018. The program's goal is to aid the U.S. Department of Transportation ("DOT") and the FAA in drafting new regulations that more holistically balance safety, privacy, and commercial interests.⁴⁷⁷

The DOT selected ten state, local, and tribal governments as participants out of 149 applications.⁴⁷⁸ Each applicant also included the partners that it would work with.⁴⁷⁹ Notable companies selected as part of the program include Apple, Microsoft, Intel, General Electric, and Google's sister company Project Wing, as well as a host of others.⁴⁸⁰ Oddly, Amazon and DJI, the largest consumer drone companies in existence, were not chosen.⁴⁸¹ The IPP creates new partnerships between local governments, the FAA, and the private industry to freely allow select drone operators to conduct "drone-based mapping, inspections, traffic and weather monitoring, commercial and medical delivery, and law enforcement surveillance systems."⁴⁸² The IPP will "accelerate the safe integration of drones into our airspace" and will allow select cities to experiment with "package delivery, emergency drone inspections, and more, on terms that work for them," according to U.S. Secretary of Transportation Elaine Chao.⁴⁸³ Of course, all of these uses require that drones fly many miles beyond the sight line of their operator.

475. Mac, *supra* note 464.

476. David Koenig, *Where Are the Drones? Amazon's Customers Are Still Waiting*, LONG VIEW NEWS J. (Dec. 23, 2018), <https://perma.cc/5TMM-CVEY>.

477. *UAS Integration Pilot Program*, FED. AVIATION ADMIN. (Nov. 7, 2018), <https://perma.cc/HS9G-8Q3G>.

478. *U.S. Transportation Secretary Elaine L. Chao Announces Unmanned Aircraft Systems Integration Pilot Program Selectees*, U.S. DEP'T TRANSP. (May 9, 2018), <https://perma.cc/B5M6-RQFV>.

479. *Id.*

480. Nick Zazulia, *DOT Selects 10 Participants for Nationwide Drone Integration Pilot Program*, AVIONICS (May 11, 2018), <https://perma.cc/BD23-6WSF>.

481. Samuel Gibbs, *Apple, Microsoft and Uber Test Drones Approved but Amazon Left Out in Cold*, THE GUARDIAN (May 10, 2018), <https://perma.cc/UY7A-WCXX>.

482. Faine Greenwood, *A New Drone Testing Program from the Trump Administration Just Gave Big Business a Big Boost*, SLATE (Jun. 15, 2018), <https://perma.cc/6ZYC-PWB6>.

483. *Announcement of DOT Drone Integration Pilot Program*, U.S. DEP'T TRANSP. (Nov. 2, 2018), <https://perma.cc/U32Q-5N3A>.

The IPP has also given the green light to Uber to use drones for food delivery in San Diego; CNN and Green Valley Farms in Oklahoma; Lee County to use drones to control the mosquito population in Florida; FedEx, Intel, and General Electric to use drones to deliver packages, and conduct autonomous flights to support airport operations in Tennessee; and Zipline, Flytrex, Matternet, PrecisionHawk, and the North Carolina Department of Transportation to use drones to deliver blood and medical supplies in North Carolina.⁴⁸⁴

Over the next few years, the ten select project sites will collect “drone data involving night operations, flights over people and beyond the pilot’s line of sight, package delivery, detect-and avoid technologies and the reliability and security of data links between pilot and aircraft.”⁴⁸⁵ The data collected from these operations will help the DOT and FAA draft more pragmatic regulations for drones that address safety and privacy concerns while permitting further commercial applications.⁴⁸⁶

By allowing drones to finally operate beyond the line of sight, companies will provide affordable convenience to the public and positively impact numerous industries. Some applications that expect to witness instant benefit from the pilot program are photography, emergency management, public safety, precision agriculture, and infrastructure inspections.⁴⁸⁷ Furthermore, commercial utilization of drones will create jobs and have a substantial economic impact in the affected communities. According to AUVSI—the world’s largest nonprofit organization dedicated to unmanned systems and robotics—drone integration into the national airspace will create more than 70,000 domestic jobs with an economic impact of more than \$13.6 billion within the first three years.⁴⁸⁸ By 2025, the organization predicts that more than 100,000 jobs will be created with a total economic impact of \$82 billion.⁴⁸⁹ While the IPP and the Trump Administration have taken positive steps, it is not nearly enough because there can be no substantial commercial or public safety application of drone technology if businesses must request permission from the FAA each time they want to fly beyond an operator’s line of sight.

484. Alan Boyle, *10 Teams Win OK To Push the Limits With Drones, but Amazon’s Left Out*, GEEKWIRE (May 19, 2018), <https://perma.cc/L6CQ-WRQT>.

485. U.S. DEP’T TRANSP., *supra* note 478.

486. *Id.*

487. *Id.*

488. *Id.*; JENKINS & VASIGH, *supra* note 21 at 2.

489. JENKINS & VASIGH, *supra* note 21 at 2.

5. Summary Observations

Thus, in order to fully realize the promise of drones,⁴⁹⁰ the FAA should immediately remove the line-of-sight requirement. First, the line of sight is a spineless regulation premised on a flawed “see and avoid” philosophy (see *supra*, Part V.A.1). The original justification that operators had to be able to see their drones to avoid contact with other aircraft has been rendered irrelevant due to technological advancements. FPV camera technology now allows operators to see and avoid obstacles without needing to directly “see” the drone with their own eyes. While the FAA understandably intended to address safety concerns, the rule now represents an unnecessarily conservative approach that limits the benefits of drones without doing anything to enhance their safety.

Second, the line-of-sight regulations dramatically restrict commercial, research, and public safety drone applications. Operators hoping to use drones for positive and productive applications that require their drones to fly miles away must overcome lengthy regulatory hurdles, such as obtaining a Part 107 waiver from the FAA—a time-consuming and burdensome approval process.

Finally, the line-of-sight rule inhibits innovation (e.g., direct drone delivery) and forces American businesses to pour their resources abroad—where more friendly drone regulations exist.⁴⁹¹ When U.S. businesses invest their resources internationally, America loses out on the opportunity to be the leader in innovating drone technologies and creating accompanying jobs. Other countries, such as the United Kingdom, Japan and Canada, are outpacing the United States in drone technology under current FAA regulations.

In sum, the FAA must eliminate its line-of-sight regulation because it is premised on flawed reasoning, is time-consuming and burdensome to waive, and in the end stifles innovation that would benefit our country.

B. Registration Is Unnecessary and Ineffective, and It Violates Privacy

Treating Like the line-of-sight regulation, the FAA’s drone registration requirement is another example of a misguided attempt to improve public safety. The registration requirement requires every recreational drone that exceeds 0.55 pounds (meaning that virtually every toy drone is included) to have the name, home address and phone number of its owner registered with the FAA.⁴⁹² In theory, the FAA believes that requiring drone operators to register their devices in advance would mitigate risk by encouraging them to fly safely and legally.⁴⁹³

490. See Robert M. Howard et al., *Congress Evaluates Regulatory Path Forward for Integrating Drones*, LATHAM & WATKINS (Aug. 15, 2019), <https://perma.cc/SA62-HL7K>.

491. *Future of Drones*, *supra* note 455.

492. Press Release, Fed. Aviation Admin., FAA Announces Small UAS Registration Rule (Dec. 14, 2015), <https://perma.cc/BBF3-265C>.

493. See *Recreational Flyers & Modeler Community-Based Organizations*, *supra* note 88.

In actuality, however, it is difficult to imagine that the FAA's drone registration requirement will operate in this manner—because bad actors will of course not abide by this regulation. No reasonable regulator could seriously believe that a terrorist would voluntarily register his weaponized drone with the federal government. Instead, law-abiding Americans, including teenagers not yet old enough to drive or vote are the parties who bear the brunt of this regulation. Moreover, registration does little to nothing to increase operator safety and unwittingly creates invasion of privacy concerns. In fact, the FAA completely ignores practical realities and the problems it creates by requiring registration—e.g., (1) illegible markings after collisions; (2) privacy violations; (3) terrorists will not comply with these rules; (4) lack of enforcement infrastructure; and (5) fraud by third parties.

1. *Registration Marks May Not Be Legible After a Collision*

The FAA's drone registration rule could—theoretically—hold drone operators “accountable to the public for flying responsibly.”⁴⁹⁴ However, this noble intent is “limited by practical realities”⁴⁹⁵ because registration markings on drones are often not legible after a serious collision.⁴⁹⁶ Thus, this requirement likely fails to deter misconduct and is an example of yet another unnecessary regulatory hurdle for drone operators.

As detailed above in Part II.B.3, the FAA's new recreational drone registration rule requires drone operators to mark their drones with an FAA registration number by engraving, permanent label, or a permanent marker.⁴⁹⁷ The FAA argued that its registration requirement “will enhance safety and security by allowing a person [like a first responder] to view the unique identifier directly without handling the drone [which might contain explosives].”⁴⁹⁸

While well-intended, this rule does nothing to increase safety and security for two reasons. First, those potentially injured or violated by drones (e.g., unwarranted surveillance, trespasses onto private property, or crashes into structures or people) are unlikely to see and remember the drone's identification number when the drone is mid-flight.⁴⁹⁹ The FAA's requirement only states that the registration number must be visible on the exterior of the drone via engravings, permanent labeling, or permanent marker.⁵⁰⁰ With such vague instructions, drone operators are technically in compliance with the FAA's registration and marking requirements if they mark their drones with a silver Sharpie in small and sloppy

494. *FAA Announces Small UAS Registration Rule*, *supra* note 492.

495. Cecilia Kang, *Drone Registration Rules Are Announced by F.A.A.*, N.Y. TIMES (Dec. 14, 2015), <https://perma.cc/M3PB-4L7F>.

496. *Id.*

497. *ID Marking Change*, *supra* note 81.

498. *Id.*

499. See Violet Blue, *Confusion Over FAA Drone Registry Results in Privacy Problems*, ADGADGET (Feb. 3, 2016), <https://perma.cc/BY58-QJPF>.

500. *How To Label Your Drone*, *supra* note 82.

handwriting under the fuselage. Accordingly, those potentially injured by drones will have the impossible task of identifying (in mid-flight) where the drone's registration number is located, attempting to decipher the handwriting, memorizing or writing down the number, while simultaneously being threatened or harmed by the drone. Simple, practical examples such as this illustrate the absurdity of the FAA's registration rule.

The reality is that a drone's identification number could likely only be obtained if the drone was captured or downed.⁵⁰¹ Even in that event, the drone may be extensively damaged by the collision or destroyed by other manners.⁵⁰² For example, a drone would be completely destroyed if it collided with an airplane, as simulated by the UDRI engineer.⁵⁰³ The likelihood that an engraved, labeled, or marked identification number on the drone would be legible even after a much smaller crash is relatively low. In sum, the FAA's registration requirement fails to realistically address how individuals harmed by drones can identify the drone owner and hold that owner accountable.

2. *Privacy Problems: Home Address, Email and Phone Number Are Freely Accessible to the Public*

The FAA's federally mandated drone registration rule will also needlessly violates the individual registrant's privacy.⁵⁰⁴ Under current FAA regulations, drones must be registered with the agency prior to flight, which requires a recreational drone operator to provide their name, physical and mailing address, email address, and phone number in exchange for an FAA-issued identification number.⁵⁰⁵ The FAA confirmed that the information provided through drone registration will be public, which means names and home addresses of drone pilots—

501. Blue, *supra* note 499.

502. Kang, *supra* note 495.

503. Gregg, *supra* note 347.

504. Blue, *supra* note 499; *see also* Andrew Tarantola, *FAA Confirms That Drone Registry Info Will Be Public Record*, ENGADGET (Dec. 18, 2015), <https://perma.cc/BW4U-4JD4>.

505. Blue, *supra* note 499; *see also* Tarantola, *supra* note 504. John Goglia, *FAA Finally Admits Names and Home Addresses in Drone Registry Will Be Publicly Available*, FORBES (Dec. 18, 2015), <https://perma.cc/TXZ5-6ULT>; Interpretation of the Special Rule for Model Aircraft; Withdrawal, 84 Fed. Reg. 14,607 (Apr. 11, 2019); John Patrick Pullen, *Getting a Drone for the Holidays? You'll Have To Register It With the FAA*, TIME (Dec. 12, 2017), <https://perma.cc/6JHM-D9T3>. In 2017, the FAA's drone registration rule was vacated by the United States D.C. Court of Appeals, which held that it "violates Section 336 of the FAA Modernization and Reform Act." *Taylor*, 856 F.3d at 1094. Additionally, this ruling held that the FAA "may not promulgate any rule or regulation regarding a model aircraft." *Id.* at 1090. Nevertheless, the registration requirement was recently reinstated by President Trump in the National Defense Authorization Act for Fiscal Year 2018. Michael Senkowski, *FAA Drone Registration Authority Restored*, DLA PIPER (Dec. 12, 2017), <https://perma.cc/G4UW-W8ES>.

as young as thirteen years old—are public information.⁵⁰⁶ As Violet Blue, an investigative reporter on hacking and cybercrime, correctly points out, “[i]f a violent person knew the first and last name of someone he or she wanted to harm, someone who also owned a drone, that attacker would have little trouble tracking them down.”⁵⁰⁷

Alternatively, drone operators can register their drones through LLCs or other entities to avoid compromising personal information.⁵⁰⁸ However, this is an expensive way to keep personal information private.⁵⁰⁹ Beyond violating drone operators’ reasonable privacy expectations, the FAA’s registration requirement misses its own purpose of fostering accountability. Instead, the FAA gives drone operators an absurd ultimatum when registering their drones: (1) expose your personal information online or (2) spend hundreds of dollars forming an entity in order to avoid disclosing your personal information.

3. *Bad Actors Are Highly Unlikely To Register Their Drones*

Furthermore, only law-abiding citizens will register their drones with the FAA, which means that drone operators with malevolent intentions, including terrorists, will not register their drones and thus their drones will not be identifiable.⁵¹⁰ Of course, the proliferation of drone usage has raised significant concerns about unwarranted surveillance or terrorist activities.⁵¹¹ But the FAA’s registration solution utterly fails because “drone users who plan to use the machines for nefarious purposes” are more than likely not to register at all.⁵¹² For example, “someone who tries to fly a drone into the approach path of an incoming passenger plane, realizing he puts all passengers (and people on the ground) at risk, is not someone who will care to first register his drone.”⁵¹³ Additionally, the FAA’s

506. Goglia, *supra* note 505;

There has been some confusion over the matter as the FAA’s registry FAQ states that the agency, the contractor that it hired to operate the registry and law enforcement which had led some to believe that only those three entities would have access to the information. However, the FAA did state in its Department of Transportation filing that ‘all records maintained by the FAA in connection with aircraft registered are included in the Aircraft Registry and made available to the public, except email address and credit card information submitted under part 48 [of the registry].’

Tarantola, *supra* note 504.

507. Blue, *supra* note 499.

508. *Id.*; *FAA Registry—Aircraft*, FED. AVIATION ADMIN. (Aug. 10, 2010), <https://perma.cc/UB7A-8DAZ>.

509. Lisa Magloff, *How Much Money Does Starting an LLC Cost?*, LEGALZOOM, <https://perma.cc/TMG7-BPQX> (archived Dec. 23, 2019).

510. Yoram Solomon, *If the FAA Regulates Drones, Why Doesn’t It Regulate Laser Pointers?*, INC. (Mar. 15, 2016), <https://perma.cc/5XNC-VZC3>.

511. *Supra* Part IV.

512. Kang, *supra* note 495.

513. Solomon, *supra* note 510.

registration process will not deter drone operators who intend to recklessly cause damage or act with complete disregard to other people or property.⁵¹⁴ Unfortunately, the law-abiding hobbyist community, including the authors of this Article, now face intrusion into their own privacy due to the FAA's registration requirement, but with zero accompanying benefit when it comes to fostering overall public safety.⁵¹⁵

4. *The FAA Lacks Any Enforcement Mechanism*

Moreover, while the FAA asserts that the registration process is intended to “help[] promote safe and responsible drone operation,”⁵¹⁶ this vision cannot be realized without an actual enforcement infrastructure system. The FAA notes that failure to register a drone could result in a substantial civil fine up to \$27,500 or criminal penalties up to \$250,000 or three years in prison.⁵¹⁷ However, in reality the threat (and deterrence impact) from these sanctions is far less draconian than it appears.⁵¹⁸ First, the agency is extremely unlikely to fine an unregistered, recreational drone operator the maximum \$27,500. Rather than setting a minimum penalty or mandatory system, the fines will be analyzed on a case-by-case basis, which presents an inconsistent and potentially exhausting enforcement problem.⁵¹⁹ For example, the FAA settled with Xizmo Media, a professional drone cinematography company who was not registered and flew recklessly, for a mere \$5000.⁵²⁰ First-time offenders and recreational users will likely receive minimal fines or just a warning.⁵²¹

Second, the FAA has not specified how the agency will enforce its registration rule.⁵²² While the FAA has established how much the potential fines could be, the agency requires other law enforcement officials to actually chase down unregistered drones—a highly unlikely effort given other priorities that the police have.⁵²³ Without its own enforcement apparatus, it is unlikely that the FAA's registration requirements will have the teeth that the agency claims. In the end then,

514. *See id.*

515. *See id.*

516. Brian Heater, *Trump Signs Bill Reinstating the FAA's Drone Registration Requirement*, TECHCRUNCH (Dec. 12, 2017), <https://perma.cc/DLD2-B6MZ>.

517. Keith Wagstaff, *Fail To Register Your Drone? You Could Be Hit With \$27K Fine*, NBC NEWS (Dec. 15, 2015), <https://perma.cc/P9GL-7X4B>.

518. *Id.*

519. *See generally* Jason Koebler, *The FAA Gave Us a List of Every Drone Pilot Who Has Ever Been Fined*, VICE (Jun. 1, 2016), <https://perma.cc/6CUE-4WP3> (finding that drone-induced fines “recklessly var[i]ed” since drone operators have paid fines “as little as \$400” or as high as \$5,500, or appealed or settled with the FAA).

520. *Id.*

521. Wagstaff, *supra* note 517.

522. *Id.* (“The [FAA] did not give any specifics on how drones would be stopped and their owners identified.”).

523. *Id.*

it is another example of a well-meaning regulation that utterly fails at realizing its goals.

5. *Registration Requirement Inadvertently Opens the Door to Fraud by Third Parties*

The FAA's registration requirement has also ironically opened the door to fraudulent registration services provided by third-party companies.⁵²⁴ These companies mislead drone operators with the "standard search-engine bait-and-switch" by charging premiums for the registration process.⁵²⁵ The registration process should only cost the drone operator \$5.00; however, the FAA recently received reports of vendors charging exorbitant fees up to \$150.00 for this service.⁵²⁶ Some third party companies even "mimic the look of the FAA's website with similar graphic design and use of the FAA logo, suggesting that they are somehow 'approved' by the agency."⁵²⁷ Through an innocent Google search, drone operators as young as thirteen years old could easily be deceived by these duplicitous third party companies.⁵²⁸

This unfortunate reality recently caught the attention of the FAA, and in response, the agency issued a press release warning drone operators to avoid registering their drones anywhere but at the FAA Drone Zone.⁵²⁹ However, the FAA states that the agency does not regulate these third-party registration entities nor will it speculate on their legitimacy.⁵³⁰ What they are really saying is, "Sorry, not sorry. This is not our problem; it's yours." What they don't acknowledge is that they created the potential for this fraud and abuse in the first place.

6. *In Sum, the FAA's Drone Registration Requirement Creates More Problems Than It Resolves, and Should Be Removed*

Clearly, the FAA's recreational drone registration rule is a toothless regulation that fails to deter drone misconduct—the very purpose for its enactment. First, the FAA cannot police its own rule and thus has no ability to hold violators accountable. Second, the FAA's theory of drone operator accountability is premised on everyone, including criminals and terrorists, registering and labeling their drones. Moreover, the registration requirement assumes markings will remain legible after a crash. In reality, however, criminals are highly unlikely to leave a

524. Rick Broida, *Avoid Fake Drone-Registration Sites*, CNET (June 7, 2016), <https://perma.cc/Q2JA-XUGY>.

525. *Id.*

526. *FAA Says Avoid Drone Registration Schemes*, FED. AVIATION ADMIN. (Jul. 11, 2018), <https://perma.cc/LFA7-D77X>.

527. *Id.*

528. Broida, *supra* note 524.

529. *FAA Says Avoid Drone Registration Schemes*, *supra* note 526.

530. *Id.*

digital trail for law enforcement to trace and most drones will likely be damaged beyond recognition in the event of a serious collision. Third, the drone registration rule exposes drone operators' private information to the public, which includes home addresses, phone numbers, and emails of drone hobbyists, some as young as thirteen years old. Finally, unscrupulous third-party companies have and will continue to defraud and take advantage of recreational drone users by offering unnecessary premiums to help everyday citizens comply with the FAA's federally mandated registration rules. The registration regulation, thus, penalizes law-abiding drone users without any significant accompanying benefits when it comes to public safety or accountability. It should be eliminated by the FAA immediately.

C. *The Invisible Fence: "Geofencing" as the Sensible Solution*

This Article has exposed the reality that the FAA's drone registration and line-of-sight regulations do little to nothing to eliminate or effectively address the legitimate threats posed by drones. The Authors acknowledge that drones do present a public safety risk (notably collisions with people, structures, and planes, as well as terrorism), they can invade privacy (e.g., individual or mass surveillance), and they can further illegal conduct (e.g., drug smuggling). The common denominator of these threats is intentional or reckless misconduct by the drone operator. While the FAA intends to remedy potential misconduct with more regulation, the agency ignores reality and has inadvertently created more problems than it has solved. To balance the public's legitimate concerns without compromising commercial, humanitarian, recreational, and law enforcement applications,⁵³¹ the FAA should instead view technology as the solution, not the enemy.

Newly developed geofencing technology uses GPS and other navigational satellite signals to prevent a drone from entering restricted areas (e.g., airspace near airports, aircraft, private homes, and the White House).⁵³² In the dominant implementation, "position technologies" onboard the drone, like GPS, locate the drone in real-time,⁵³³ drone manufactures program the drones to stay out of marked locations, and the database of marked locations is updated by manufacturers and pushed to internet-connected drones—hence protecting locations using programmed fences around geographies, or "geofences."⁵³⁴

531. *Supra* Part III.

532. Wadell, *supra* note 25; Press Release, DJI, DJI Improves Geofencing to Enhance Protection of European Airports (Feb. 12, 2019), <https://perma.cc/FB32-ZRGE>.

533. Phillip Smith, *Drones and Geofencing: How It Works, Benefits & Requirements*, DRONEBELOW (Jun. 26, 2018), <https://perma.cc/H95F-2E3K>; Wadell, *supra* note 25.

534. Press Release, PrecisionHawk, PrecisionHawk Announces DJI Partnership (Oct. 24, 2018), <https://perma.cc/4LZY-NWQ8>; Wadell, *supra* note 25. Other implementations could depend less on manufacturers and less on upfront programming. As one approach, manufacturers might program the drones to respect marked geographies, while others—whether the

This geofencing technology is versatile. Temporary geofences can be set up around huge public events (e.g., the Super Bowl, parades, or concerts), hazardous locations (e.g., wildfires, pipeline explosions, nuclear plants), or people (e.g., the president).⁵³⁵ It is nuanced. For example, DJI's GEO 2.0 geofencing, which all its drones have,⁵³⁶ shows operators "where it is safe to fly, where flight may raise concerns, and where flight is restricted."⁵³⁷ These areas are defined as Restricted Zones, Authorization Zones, Enhanced Warning Zones, or Warning Zones, based on air traffic and sensitive areas like airports, prisons, and power plants.⁵³⁸ Of these designated zones, only Restricted Zones prevent drones from entering.⁵³⁹ Authorization Zones permit entrance after verification.⁵⁴⁰ And Enhanced Warning Zones and Warning Zones simply prompt a warning message to drone operators.⁵⁴¹ (As for how the restrictions work in practice: Geofencing can trigger programming that forces a drone to land if it flies near or into a restricted area, or that even incapacitates a drone in midair.⁵⁴² Thus, drones programmed with geofencing technology cannot fly into restricted areas, even if an operator seeks to fly into those areas.) And this geofencing technology is increasingly precise. For example, DJI, the world's leader in civilian drones, partnered with PrecisionHawk to enhance its geofencing technologies.⁵⁴³ By relying on PrecisionHawk's Low Altitude Traffic and Airspace Safety (LATAS) platform (i.e., geospatial information), DJI can better refine and define airspaces to enhance its geofencing technologies.⁵⁴⁴ Finally, this technology is increasingly widely available, as it is being programmed into certain publicly available consumer drones.⁵⁴⁵

FAA, or even disaggregated parties such as sports stadium owners or presidential security personnel—would directly add new protected geographies at any time. Those other parties might do so by updating the database of marked geographies or by physically installing an object that emits a signal to the drone to mark the geography. As another approach, manufacturers might not program the drones at all, while third parties could install systems to detect when a drone crosses a perimeter and to trigger a response to impair the drone's flight. Each approach may have different advantages and detractions.

535. See Wadell, *supra* note 25.

536. DJI, *ELEVATING SAFETY: PROTECTING THE SKIES IN THE DRONE ERA* (2019).

537. *Fly Safe Geo Zone Map*, DJI, <https://perma.cc/8GMP-YA3C> (archived Nov. 9, 2019).

538. *Id.*

539. *Id.*

540. *Id.* ("In an Authorization Zone, all flight is restricted by default, but users can self-unlock [this zone] with a DJI-verified account.")

541. *Id.*

542. Eric Adams, *NASA's Safeguard Tech Stops Trespassing Drones Without Touching Them*, *WIRED* (July 12, 2017), <https://perma.cc/7WJZ-GCK7>.

543. See DJI, *supra* note 536.

544. *Id.*

545. *Id.*

However, not all drone manufacturers provide such technology in their drones, and those that do provide geofencing do not all follow the same standards.⁵⁴⁶ And ultimately, the effectiveness of geofencing will depend on mass adoption of consistent geofencing technology. Further, the database of protected locations might be hacked, or updates from the database to a particular drone might be prevented.

Still, the needed coordination could be achieved, and the vulnerability to bad actors here is no worse—indeed, it’s significantly less—than under the status quo of the FAA’s legal but not technical measures. From a coordination standpoint, DJI owns about 74% of the drone market as of 2017,⁵⁴⁷ and has taken a leadership in drone technology and safety; it could spearhead industry-wide standards. From a bad actor standpoint, there is currently nothing preventing bad actors from disrespecting the FAA’s legal pronouncements. Most of all, there is nothing preventing merely negligent actors from flying their drones into FAA airspace. Even with the challenge of standardization and the limitations of this technology against motivated adversaries, geofencing remains a far more realistic solution to the drone-induced fears than does the FAA’s current regulatory response.⁵⁴⁸

Additionally, geofencing can and is *quickly* improving to fix technological deficiencies and to accommodate the evolution of drone technology, unlike the FAA. For example, DJI immediately⁵⁴⁹ announced it would improve its geofencing technology in response to drone sightings near Gatwick Airport (i.e., a restricted area), the United Kingdom’s second-largest airport.⁵⁵⁰ Although this event was unrelated to terrorism, this deliberate misconduct⁵⁵¹ briefly suspended all flights and caused a host of negative externalities.⁵⁵² In response, DJI created a “three-dimensional bow tie” geofence, which is more comprehensive than prior

546. Ryan Wallace et al., *Evaluating Small UAS Near Midair Collision Risk Using AeroScope and ADS-B*, 5 INT’L J. AVIATION, AERONAUTICS, & AEROSPACE, 2018, at 26.

547. Sally French, *DJI Market Share: Here’s Exactly How Rapidly It Has Grown in Just a Few Years*, THE DRONE GIRL (Sept. 18, 2018), <https://perma.cc/US2M-UVVA>.

548. Andrew Meola, *The FAA Just Put Up a Major Roadblock to Widespread Drone Usage*, BUS. INSIDER (May 5, 2016), <https://perma.cc/73FN-WUSR> (noting that “geo-fencing and collision avoidance will make flying drones safer and make regulators feel more comfortable with larger numbers of drones”).

549. Within two months, DJI announced that it will improve its geofencing to enhance protection of European airports and facilities. In December 2018, a drone was spotted near Gatwick Airport, which caused the airport to temporarily shut down. In February 2019, DJI announced, via press release, that the company would improve its geofencing technology to prevent similar drone misconduct. Press Release, DJI, *DJI Improves Geofencing To Enhance Protection of European Airports and Facilities* (Feb. 12, 2019), <https://perma.cc/V9A5-M6MQ>.

550. Jon Porter, *DJI Will Toughen Up Airport Geofencing After Recent Drone Disruption*, THE VERGE (Feb. 13, 2019), <https://perma.cc/GVY9-QWLW>.

551. Benjamin Mueller and Amie Tsang, *Gatwick Airport Shut Down by ‘Deliberate’ Drone Incursions*, THE NEW YORK TIMES (Dec. 20, 2018), <https://perma.cc/J7ZW-BXJJ>.

552. *Id.*

geofencing methods, to prevent this type of drone misconduct.⁵⁵³ Coined “Geo-spatial Environment Online 2.0,” DJI’s new geofencing system uses “complex polygon shapes around other sensitive facilities, rather than just simple circles used in earlier geofencing versions,”⁵⁵⁴ as shown in Figure 3.

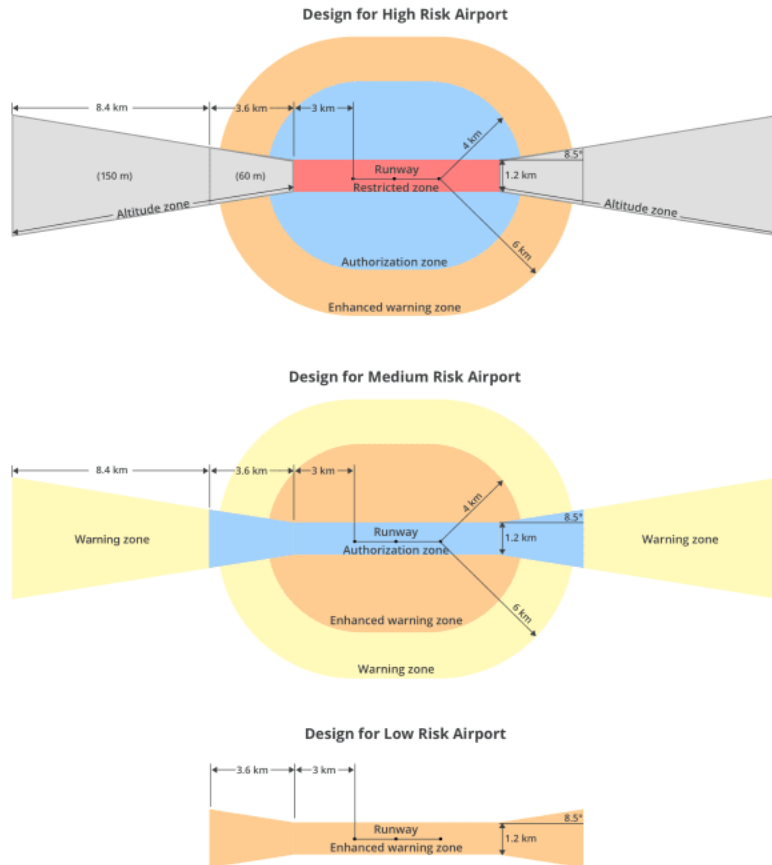


FIGURE 3.

DJI’s new GEO 2.0 uses three-dimensional polygon shaped geofencing technology instead of two-dimensional circles.

553. DJI Improves Geofencing To Enhance Protection of European Airports and Facilities, *supra* note 549.

554. *Id.*

While current FAA regulations allegedly already prevent drones from flying into restricted areas, “there is nothing [physically] preventing an operator from overstepping these [regulations] aside from her ‘good faith.’”⁵⁵⁵ Unfortunately, bad actors typically do not possess good faith and thus render certain FAA regulations wholly ineffective. The FAA should recognize this reality and remove ineffective regulations immediately. Next, it should replace them with far more effective technological solutions that actually enhance public safety and privacy. Geofencing technology is a far better approach than existing FAA regulations because the technology moves faster than legislation to adapt to necessary changes and is more effective than legislation. By utilizing technological solutions, drone misconduct can be deterred more effectively than with toothless regulations like mandated drone registration and line-of-sight rules.

VI. CONCLUSION

Whatever the future of the regulatory landscape for drones holds, one thing is crystal clear: drones have the potential to transform how businesses operate and innovate, how scientists gather data and protect species, and how law enforcement agents save lives.⁵⁵⁶ While the safety concerns posed by drone technology are legitimate,⁵⁵⁷ government regulators must keep in mind that these risks are exceedingly remote compared to the benefits of drone technology.⁵⁵⁸ The FAA’s regulatory oversight—especially its line-of-sight and registration requirements—stifle innovation and are less effective in enhancing public safety than the technology they seek to restrict.⁵⁵⁹ In the end, the FAA must take a more pragmatic approach to airspace safety, aimed at balancing costs and benefits in order to maximize overall social welfare.

Specifically, this Article proposes a two-part framework for reform that aims to allow the benefits of drone technology to be realized while not compromising privacy or public safety.⁵⁶⁰ First, we propose that the FAA remove the line-of-sight requirement from its drone regulatory framework.⁵⁶¹ The mandate forces pilots to keep their drone within sight at all times, effectively precluding numerous beneficial applications, including long distance scientific research, commercial delivery, and first-person-view recreational use.⁵⁶² While the FAA thought this requirement would improve safety by allowing operators to view and avoid

555. Victoria Chang et al., *Spiders in the Sky: User Perceptions of Drones, Privacy, and Security*, PROC. 2017 CHI CONF. ON HUM. FACTORS IN COMPUTING SYS. 6765 (2017).

556. *Supra* Part III.

557. *Supra* Part IV.

558. *Supra* Part V.A.4 and Part V.B.6.

559. *Supra* Part V.

560. *Supra* Part V.C.

561. *Supra* Part V.A.

562. *Id.*

obstacles in their path, modern first-person-view technology (utilizing tiny cameras inside drone cockpits to transmit live views to the pilot) are a far more effective way for pilots to detect threats and avoid collisions.⁵⁶³ Keeping drones within one's eyesight at all times not only stifles future innovation, but is entirely unnecessary given other mechanisms that accomplish the same goal.

Second, the intrusive registration process that the FAA requires for all consumer drones should be repealed immediately.⁵⁶⁴ Requiring teenagers to register their Christmas toys with the federal government—handing over their phone number, home address and email in a publicly searchable database—does little to address the safety of our skies. Conversely, it raises a very real privacy violation (of minors no less), and creates an unnecessary regulatory hurdle for law-abiding hobbyists who are unlikely to pose a terrorist threat.⁵⁶⁵ True terrorists tend not to register their devices with Uncle Sam in advance, regardless of what the law requires them to do.

Finally, this Article recommends that the FAA outsource the process of creating restricted drone flying space to private companies who are far better-equipped to do this directly through the use of “geofencing” technology.⁵⁶⁶ Presently, individual pilots are expected to keep track of the constantly changing restrictions on flying zones imposed by the FAA, and keep their drones outside of them.⁵⁶⁷ However, drone manufacturers can accomplish this goal directly via software and GPS signals that keep drones within their allowed flight zones and incapacitate those that stray.⁵⁶⁸ Whether malicious or unintentional, drone-induced collisions or risks can be prevented altogether by technology, rather than relying on the skill or good faith of human pilots. This geofencing technology can also be updated in real time to instantly modify temporarily restricted airspace, for instance in the event of a Presidential visit to a specific location or a major event like the Superbowl.⁵⁶⁹

In sum, the FAA must reconsider the benefits and costs of its drone regulations, lest we stifle the incredible advancements that the technology promises to offer. The reforms proposed above are not that difficult to implement, and the technology already exists. The only thing left is for Congress and the FAA to act.

563. *Supra* Part V.A.1.

564. *Supra* Part V.B.

565. *Id.*

566. *Supra* Part V.C.

567. *FAA Highlights Changes for Recreational Drones*, *supra* note 67; *U.S. Air Space Map*, KNOW BEFORE YOU FLY, <https://perma.cc/DVC8-WRL8> (archived Nov. 7, 2019).

568. *Supra* Part V.C.

569. *Id.*