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Law Abiding Drones

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I. INTRODUCTION

Drones[1] have the Federal Aviation Administration (FAA) scrambling. They are popping up all over the place: conducting aerial surveys of industrial construction sites,[2] making stunning

1. This article uses the popular term "drone" rather than a variety of politically correct terms such as Unmanned Aerial Vehicle, Pilotless Aircraft, or the FAA's preference, "Unmanned Aircraft Systems" ("UAS"). It makes exceptions, and uses the terms UAS or sUAS when the context of FAA statements makes use of the official terminology more appropriate. "Drone" is simpler and is 100 times more popular than the term "unmanned aircraft system." A Google search on 12 February 2015 using the word "drone" produced 98,700,000 hits. A search on the phrase "unmanned aircraft system" produced only 986,000 hits.

2. *See* Jack Nicas, *Drones' Next Job: Construction Work*, WALL ST. J. (Jan. 20, 2015, 10:59 AM), http://www.wsj.com/articles/drones-next-job-construction-work-1421769564.

promotional movies of high-end residential properties,[3] capturing videos of breaking news for TV stations,[4] surveying crops,[5] and monitoring the integrity of power lines and pipelines.[6] Finally, the FAA has released a long-awaited notice of proposed rulemaking ("NPRM") that offers a sensible framework for regulating this new aviation technology.[7] Before release of the NPRM, the FAA had been sending warnings,[8] imposing fines, and trying to defend its ban on the commercial use of what it calls small Unmanned Aircraft Systems or "sUAS"—microdrones, in plain speak. Like King Canute,[9] the FAA was trying to hold back the tide.

Local authorities and the aviation community also are concerned. Incidents in which the police act against microdrone

3. Joel Aschbrenner, *FAA says real estate agents' drone use illegal*, USA TODAY (July 7, 2014, 6:12PM), http://www.usatoday.com/story/news/nation/2014/07/07/real-estate-drones-illegal/12299591/ (reporting on popularity for real estate sales promotion and agriculture); Robert Freedman, *Drones in Real Estate: Not so Fast*, REALTOR MAG. (Mar. 2014), http://realtormag.realtor.org/law-and-ethics/briefs/article/2014/03/drones-in-real-estate-not-so-fast ("Some real estate companies are chomping at the bit to incorporate drone photography into their marketing . . .").

4. *Will TV news helicopters be replaced by drones?*, CBS NEWS (May 16, 2013, 2:53 PM), http://www.cbsnews.com/news/will-tv-news-helicopters-be-replaced-by-drones/ (quoting head of Radio and Television Digital News Association that "the prospect of a news drone is . . . imminent").

5. *See* PRECISION DRONE, DRONES FOR AGRICULTURAL CROP SURVEILLANCE, http://www.precisiondrone.com/agriculture/ (last visited Mar. 12, 2015).

6. Todd Woody, *Drones Are Becoming Energy's New Roustabouts*, N.Y. TIMES (Apr. 21, 2014), http://www.nytimes.com/2014/04/22/business/energy-environment/drones-are-becoming-energys-new-roustabouts.html?_r=0 (reporting on use of drones to monitor power lines and pipelines).

7. FAA, Notice of Proposed Rulemaking: Operation and Certification of Small Unmanned Aircraft Systems, RIN 2120-AJ60, Docket No. FAA-2015-0150 (Feb. 15, 2015), http://www.faa.gov/regulations_policies/rulemaking/recently_published/media/2120-AJ60_NPRM_2-15-2015_joint_signature.pdf [hereinafter "NPRM"].

8. *See* Jack Nicas, *Man vs Drone: Some Pilots Fight Back Against Robots*, WALL ST. J. (Jan. 15, 2015, 1:47 PM), http://www.wsj.com/articles/man-vs-drone-some-pilots-fight-back-against-robots-1421347663 (reporting FAA inspector's order to "stop operations immediately," and comment by drone operator that he ignored the warning and is still operating).

9. *See Canute 'The Great' (r. 1016-1035)*, THE OFFICIAL WEBSITE OF THE BRITISH MONARCHY, (last visited Mar. 12, 2015) http://www.royal.gov.uk/HistoryoftheMonarchy/KingsandQueensofEngland/TheAnglo-Saxonkings/CanutetheGreat.aspx (explaining legend that King Canute demonstrated humility by showing that his command could not arrest the waves).

operators are increasing,[10] and some pilots of manned aircraft are reporting drones flying dangerously close to them.[11]

The capabilities of the several dozen microdrone models now on the market, at prices ranging from a few hundred to a few thousand dollars,[12] are breathtaking. They can fly lower and closer to subjects than helicopters safely can; they can capture full-motion video and stream it live; they can automatically hover and fly a pre-programmed flight path.[13] They also, however, create risks of collision with manned aircraft, raise concerns about injuring people on the ground, and are perceived as creating new threats to personal privacy. The risk/reward calculations are going to be worked out in the skies and in courtrooms around the country unless the FAA gets its act together.

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10. *See* Morgan Winsor, *NY man arrested for allegedly flying drone over U.S. Open venue*, CNN (Sept. 4, 2014, 6:22 PM), http://www.cnn.com/2014/09/04/justice/new-york-us-open-drone/ (reporting arrest by municipal police for "reckless endangerment, violation of a local law, and failure to comply with a sign"); Andrew Meyer, *Police Aggressively Pursue "Drones," Arresting Aerial Photographers in NY and Ohio*, PINAC (July 16, 2014), http://photographyisnotacrime.com/2014/07/police-aggressively-pursue-drones-arrest-operators-ny-ohio/.

11. *See* Barrie Barber, Tiffany Y. Latta, & Andy Sedlak, *Drone disrupts CareFlight landing*, DAYTON DAILY NEWS (Aug. 28, 2014, 9:11 AM), http://www.daytondailynews.com/news/news/local/drone-disrupts-careflight-landing/ng94n/ (reporting that EMS helicopter carrying a patient was forced to delay landing as hospital because of drone taking photographs of nearby fairgrounds). Some of the reports of near collisions are exaggerated. Raphael Orlove, *Clueless Cops Fly Helicopter At Drone, Arrest The Drone Pilots*, JALOPNIK (July 11, 2014, 11:15 AM), http://jalopnik.com/clueless-cops-fly-helicopter-at-drone-arrest-the-drone-1603528912 (quoting air traffic control recordings that show police helicopter pursued drone rather than fearing that it presented a collision risk).

12. *See* B&H, http://www.bhphotovideo.com/c/buy/PTZ-POV-Cameras/ci/25264/N/3907816535 (last visited Mar. 12, 2015) (offering DJI Phantom 1.1.1 with GoPro mount for $479 and DJI Inspire for $3,399); 3DR, https://store.3drobotics.com/products/iris (last visited Mar. 12, 2015) (offering basic IRIS+ for $750); QUADROCOPTER, http://www.quadrocopter.com/for-Professionals_c_113.html (offering Cine Star-X8 MK Heavy Lift for $7,415) (last visited Mar. 12, 2015).

13. *See* Nicas, *supra* note 8 (quoting commercial helicopter pilot who also flies drones that microdrones can do some things helicopters cannot and that helicopters can do other things that microdrones cannot).

Microdrones[14] present more of a near-term challenge than machodrones.[15] Their low price, the ease with which anyone can operate them with a few hours of practice, and their utility for capturing high-quality video has boosted sales into the hundreds of thousands.[16]

Release of the long delayed notice of NPRM[17] opens possibilities for resolving the fundamental conflict between new technologies and the FAA's traditional approach to regulation. The content of the NPRM reflects a realization that the FAA's traditional approach to regulating aircraft design, pilot and mechanic

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14. Microdrones are small aircraft without a pilot on board. While there is no consensus about an upper weight limit for this category, the most popular ones weigh less than 10 pounds. *See*, DJI, http://www.dji.com/product/phantom-2/spec (last visited Mar. 12, 2015) (specifying DJI Phantom weight as 1,000 grams–2.2 pounds); 3DR, http://3drobotics.com/iris/?_ga=1.86234840.1577568507.1423754283 (last visited Mar. 12, 2015) (reporting weight of IRIS+ as 1282 grams--2.8 pounds).

15. Machodrones are larger aircraft without pilots on board. It is useful to consider them as weighing more than 55 pounds—the upper weight limit for sUAS defined in § 331(6), FAA Modernization and Reform Act of 2012, Pub. L. 112–95, 126 Stat. 11 (Feb. 14, 2012) (defining small unmanned aircraft system as one weighing less than 55 pounds). The Insitu Integrator has a maximum weight of 135 pounds. INSITU, http://www.insitu.com/systems/integrator (last visited Mar. 25, 2015). FlightechSystems' ALTEA weighs 397 pounds. FLIGHTECHSYSTEMS, http://flightechenglish.weebly.com/uav.html (last visited Mar. 25, 2015). Few of them are available yet for the civilian market.

16. Frank Bi, *Drone Sales Soar Past $16 Million on eBay*, FORBES (Jan. 28, 2015, 6:05 AM), http://www.forbes.com/sites/frankbi/2015/01/28/drone-sales-soar-past-16-million-on-ebay/ (reporting sales of more than 127,000 sales of microdrones on eBay since March 2014); Clay Dillow, *Get ready for 'Drone Nation,'* FORTUNE (Oct. 8, 2014, 3:58 PM), http://fortune.com/2014/10/08/drone-nation-air-droid/ (reporting sales and pre-orders of $1.2 million); Philip E. Ross, *Chris Anderson's Expanding Drone Empire*, IEEE SPECTRUM (Feb. 27, 2014, 10:19 AM), http://spectrum.ieee.org/aerospace/aviation/chris-andersons-expanding-drone-empire (reporting that 3D Robotics is selling 300 microdrones per month and has doubled sales each year).

17. The 2012 Act requires a plan to integrate drones into the national airspace system by Sept. 30, 2015. 2012 Act § 332(a)(3). Section 333(a) requires a determination by the FAA as to whether microdrones may be operated safely before the general deadline. This determination was due 180 days after enactment of the 2012 Act–August of 2012. 2012 Act § 333(a). *See*, Jeff Foster, *KEEP CALM: The FAA and sUAVs/Drone Rules Examined*, PVC (Dec. 10, 2014), http://www.provideocoalition.com/drone-law-update-faa (commenting on repeated delay on issuance of NPRM); Gregory S. McNeal, *FAA's Proposed Drone Rules May Address Toy Drones*, FORBES (Jan. 29, 2015, 11:26 AM), http://www.forbes.com/sites/gregorymcneal/2015/01/29/in-a-surprise-change-faas-proposed-drone-rules-will-address-toy-and-hobbyist-drones/ (reporting that draft NPRM is awaiting approval by the Office of Management and Budget (OMB) as of the end of 2014).

qualification, and flight operations[18] are unenforceable against microdrones. This Article evaluates the NPRM and identifies microdrone design criteria that can mitigate risks under whatever version of the NPRM becomes final. Under this approach, drone software limits height, distance flown from the operator ("Drone Operator" or "DROP"),[19] and excludes the drone from congested airspace, such as that around airports densely populated by manned aircraft. The Article dubs this as permitting only "law-abiding drones" to be sold.

The thesis of this Article is that the FAA's NPRM is a well-crafted starting point for microdrone regulation, one that avoids trying to shoehorn microdrones into traditional regulatory frameworks designed for airplanes and helicopters. The FAA may well decide to go beyond the NPRM, and require that microdrones use existing navigation and control technologies—already built in to many models–to obey the law automatically, without regard to what their operators may want them to do.[20]

The FAA has embraced a new regulatory philosophy that takes into account the unprecedented characteristics of these air vehicles and their likely operators. A new approach to regulating microdrones is necessary, because the traditional regulatory approach is manifestly unworkable with respect to these consumer products. Machodrone regulation, on the other hand, may work under adaptations of traditional rules for aircraft certification, airman qualification, and flight rules. In any event, much more time is available to the agency to work out the details of machodrone regulation, because machodrones, unlike microdrones, have not yet found their niche in the marketplace.

This Article builds on one published by the *Vanderbilt Journal of Entertainment Law and Technology* in early 2015.[21]

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18. *See UAV070 Preview of the FAA sUAS NPRM*, UAV DIG. (Nov. 28, 2014), http://theuavdigest.com/uav070-preview-of-the-faa-suas-nprm/ (reporting that NPRM will address drones weighing less than 55 pounds, require DROPs to have a manned-aircraft pilot's license, and limiting flying to daytime, below 400 feet and within line of sight).

19. This usage aligns with that of the NPRM, which creates a new category of "operator," rather than using the term "pilot." NPRM, *supra* note 7, at 59-60.

20. *But see* Kevin Poulsen, *Why the US Government Is Terrified of Hobbyist Drones*, WIRED (Feb. 5, 2015, 5:15 AM), http://www.wired.com/2015/02/white-house-drone/ (criticizing georeferencing that limits microdrone flights).

21. Henry H. Perritt, Jr. & Eliot O. Sprague, *Drones*, VANDERBILT J. ENT. & TECH. L. (forthcoming 2015) (hereinafter "Perritt & Sprague"). *See also* Henry H. Perritt, Jr. & Eliot O. Sprague, *Is there a drone in your future?* HELIWEB, 1, 14 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Drone Dread,* ROTOR &

While the first provides a detailed analysis of drone technology and mission flight profiles, this one evaluates the FAA's approach in the NPRM, emphasizing the content of a suitable regulatory regime for microdrones, focusing on vehicle design characteristics.[22]

The Article then explains how many practical restrictions on microdrone flight will be developed and enforced informally by interaction between DROPs and persons who fear injury from microdrones. It also analyzes civil litigation strategies available to microdrone operators and their antagonists, and the likely content of liability insurance coverage limitations imposed by insurers as a result of tort litigation. Ultimately, the efficacy of FAA regulation will depend upon coupling sensible regulations with economic and social incentives for safe commercial operation of microdrones.

The Article explores new technologies, now only being conceptualized under NASA-sponsored research, that could create pockets in the National Airspace System (NAS) where drones delivering packages to neighborhoods would be dispatched by an automated network that would protect other drones, manned aircraft, and people or objects on the ground.[23]

Finally, the Article explains that the nature of microdrone flight is likely to shift the traditional boundary between federal, state, and local regulation, allowing greater scope for state and local law. It suggests that the legal landscape can be improved by some measure of uniformity in state and local regulation, and proposes

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WING MAG. 34, 36 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *But Who's Going to Fly Them?* PROFESSIONAL PILOT 94, 94-96 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Law and Order in the skies,* THE TECH 4, 4 (June 2014) (MIT student newspaper); Henry H. Perritt, Jr. & Eliot O. Sprague, *Leashing Drones Don't Drone Me, Bro*, ROTORCRAFT PRO 37, 37-43 (July 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Law abiding drones*, ROTOR & WING MAG. 1, 4 (Sept. 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Seeking Law Abiding Drones: What to Tell Clients that Want to Use Drones in Their Business*, BUSINESS LAW TODAY 1, 1-4 (Oct. 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Ready for the microdrone races*? NEWSL. OF THE RADIO TELEVISION DIGITAL NEWS ASS'N. (Oct. 29, 2014), *available at* http://www.rtdna.org/article/ready_for_the_microdrone_races#.VQHaCfnF98E; Henry H. Perritt, Jr. & Eliot O. Sprague, *Reining in the Renegades*, VERTICAL MAG. 8, 8 (Dec.–Jan. 2014-2015); Henry H. Perritt, Jr. & Eliot O. Sprague, *Drones* (2014), *available at* http://scholarship.kentlaw.iit.edu/fac_schol/804; Henry H. Perritt, Jr. & Eliot O. Sprague, DOMESTICATING DRONES: THE TECHNOLOGY, LAW, AND ECONOMICS OF UNMANNED AIRCRAFT (forthcoming Oct. 2015).

22. A subsequent article considers mechanisms for training, testing, and certifying DROPs.

23. *See* Part V.

that the National Commissioners on Uniform State Laws write a uniform microdrone law.

Privacy concerns, which have dominated the popular press and media and much of the law review literature, are outside the scope of this Article, just as they are outside the scope of the NPRM.[24] The main privacy advocacy groups are quite sophisticated about this, as they are with other technologies, and they have offered detailed and pragmatic suggestions for reducing threats to personal privacy occasioned by widespread drone use.[25]

Macrodrones require less novel regulatory strategies, because existing rules for manned aircraft are more suitable for these larger aircraft.[26] Eventually, commercial machodrones will be the size of helicopters or airplanes. For example, the U.S. Air Force Global Hawk machodrones are capable of flying at much higher altitudes for longer distances, and weigh tens of thousands of pounds.[27] For them, the more traditional approach of airworthiness certification of all the details of particular models ("types"),[28] a process that usually takes several years and costs millions of dollars,[29] may be suitable. Likewise, traditional pilot licenses may be appropriate for their drone operators. Because of their greater

24. *See generally* NPRM, *supra* note 7, at 36 (noting that privacy lies outside the scope of NPRM, committing to multi-stakeholder process led by NTIA, and observing that state law and other legal productions may provide recourse for microdrone-occasioned invasions of privacy).

25. *See DRONES: Eyes in the Sky*, EPIC (Oct. 2014), https://epic.org/privacy/surveillance/spotlight/1014/drones.html (proposing privacy safeguards); Harley Geiger, *How Congress Should Tackle the Drone Privacy Problem*, CDT (May 4, 2012), https://cdt.org/blog/how-congress-should-tackle-the-drone-privacy-problem/ (proposing specific legislative requirements).

26. The FAA recognizes that machodrones present greater risks and intends to defer rulemaking for them. *See* NPRM, *supra* note 7, at 34 (noting that machodrones will "operate well beyond the operational limits" proposed in the NPRM, but because they pose greater amounts of risk, will be subject to rulemaking).

27. Northrop Grumman's RQ-4 Global Hawk, flown by the U.S. Air Force and the U.S. Navy, has a gross weight of 32,250 pounds. NORTHROP GRUMMAN, 5 (May 2008), http://www.northropgrumman.com/capabilities/rq4block20 globalhawk/documents/hale_factsheet.pdf. By comparison the Embraer E-Jet family of transport aircraft, in wide use by U.S. and foreign airlines, has gross weights of 36,000 to 48,000 pounds. *Embraer E-Jet family*, WIKIPEDIA http://en.wikipedia.org/wiki/Embraer_E-Jet_family (last visited May 17, 2015).

28. *See* 14 C.F.R. §§ 21-35 (2015) (FAA airworthiness certification standards).

29. Dan Johnson, *The Cost of Certification,* GEN. AVIATION NEWS (Sept. 9, 2012) http://generalaviationnews.com/2012/09/09/the-cost-of-certification/ (estimating cost of type certification for new aircraft as $25 million).

weight and speed,[30] and because they will be flown at higher altitudes,[31] well beyond line of sight,[32] machodrones pose risks that are much different from those posed by microdrones, and a completely different regulatory approach is appropriate for the two categories.

Indeed, airworthiness certification, DROP training, and operating rules for machodrones may end up costing so much and restricting the operations to such an extent that they will have difficulty finding a niche in the marketplace. For the foreseeable future, manned helicopters will be able to do anything machodrones can do with more agility, lower cost, and greater safety. It turns out that creating and building a robot that imitates a human pilot is quite challenging.[33]

II. CURRENT TECHNOLOGICAL AND LEGAL CONTEXT

A. Technologies and their implementations

Microdrones are small aircraft—usually rotary wing in configuration—that typically have electric propulsion in the form of separate electric motors for each of several rotors.[34] Four, six, or eight rotors are typical, because those numbers facilitate yaw, roll, and pitch[35] control by differentially varying rotor thrust. Multiple

30. *See* § C.a (explaining why the limited weight and speed of microdrones reduces their kinetic energy and therefore the amount of damage resulting from a collision).

31. *See* § C.b (explaining why limiting the height at which microdrones can be flown reduces the danger of collisions with manned aircraft).

32. *See* § C.c (explaining why keeping microdrones within the line of sight of DROPs reduces risk).

33. Pilots can react to unexpected emergencies better than robots, which can only handle situations for which they are programmed. The human perceptual apparatus is more sophisticated than what can be designed into robots. *See generally* Charles C. Kemp, Aaron Edsinger & Eduardo Torres-Jara, *Challenges for Robot Manipulation in Human Environments*, IEEE ROBOTICS & AUTOMATION MAG. 20, 20-29, (Mar. 2007), http://www.cs.cornell.edu/~asaxena/papers/challenges_for_robot_manipulation.pdf (analyzing challenges for robots intended to operate in human environments).

34. *See All Products*, DJI, http://www.dji.com/products (last visited Mar. 9, 2015) (photographs of microdrones); 3D ROBOTICS, http://3drobotics.com/ (last visited Mar. 9, 2015) (same); *For Professionals*, QUADROCOPTER, http://www.quadrocopter.com/for-Professionals_c_113.html (last visited Mar. 9, 2015) (same).

35. Yaw refers to movement about a vertical axis, as by a human being turning his head left and right. Roll refers to movement about a front-to-back axis, as by a human being tilting his body left and right. Pitch refers to movement about a left-to-right axis, as by a human being tilting his body forward and backward. In

rotors and electric propulsion simplify design and construction because they eliminate the need for a tail rotor, which consumes as much as thirty percent of the available horsepower on a typical helicopter without adding to lift.[36] Varying thrust by changing RPM rather than by changing blade pitch eliminates the need for complex mechanical drive trains involving gearboxes, drive shafts, controls rods, swashplates, and pitch links.

Several dozen microdrones are on the market, promoted for: law-enforcement support, electronic news gathering, aerial surveys, aerial photography to promote real estate, powerline and pipeline patrol, and search and rescue. Typical of the high end models are the Cinestar 8 HL[37] and the DJI S1000.[38] Typical of the low end are the 3D Robotics IRIS+[39] and the Phantom 2 Vision.[40] All of them carry cameras and are capable of performing the enumerated functions. The Phantom is the star of much print and video coverage of drones.[41] In late 2014, DJI introduced the Phantom's big brother: the DJI Inspire, with greater capability and a mid-range price tag.[42]

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a rotary wing aircraft, the pilot flies forward by pitching forward, backward by pitching backward, left by rolling left, and so on. He orients the aircraft left and right by yawing left and right.

36. *Torque*, COPTERS, http://www.copters.com/aero/torque.html (last visited Mar. 9, 2015) (reporting up to thirty percent of engine power required to drive tail rotor).

37. *See CineStar 8*, FREEFLY, http://www.freeflysystems.com/products/cinestarHL.php (last visited Mar. 9, 2015).

38. *See Spreading Wings S1000+*, DJI, http://www.dji.com/product/spreading-wings-s1000-plus (last visited Mar. 9, 2015).

39. *See IRIS+*, 3D ROBOTICS, https://store.3drobotics.com/products/iris (last visited Mar. 9, 2015).

40. *See Phantom 2 Vision*, DJI, http://www.dji.com/product/phantom-2-vision (last visited Mar. 9, 2015).

41. *See* Gregory S. McNeal, *Flying A Drone Through Fireworks May Land You in Prison*, FORBES (July 4, 2014, 2:24 PM), http://www.forbes.com/sites/gregorymcneal/2014/07/04/video-shows-drone-flying-through-fireworks/ (story on Phantom flying through July 4th fireworks); 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), http://www.nytimes.com/2015/01/28/us/white-house-drone.html (describing Phantom crash on White House lawn); Larry Celano, *NYPD copter, drone have near-miss over Brooklyn*, NEW YORK POST (Sept. 17, 2014, 10:12 PM), http://nypost.com/2014/09/17/nypd-helicopter-has-near-miss-with-drone-in-skies-over-brooklyn/ (describing arrest of operator of Phantom in New York).

42. *See Inspire 1*, DJI, http://www.dji.com/product/inspire-1 (last visited Mar. 9, 2015).

B. Risks to the National Airspace System

Whenever things fly around, they present several different kinds of risks. They can run into each other, which endangers airborne life and property. They can crash, either incident to a mid-air collision or otherwise, endangering life and property on the ground. They can drop things, either intentionally or accidentally, which also endangers life and property. Furthermore, they can make lots of noise, which disturbs peace and tranquility. For this reason, most things that fly – Boeing 787s, executive jets, recreational helicopters, electronic news gathering ("ENG") helicopters, emergency medical services ("EMS") helicopters, light airplanes, hot air balloons, and blimps – are subject to a complex set of rules developed by the FAA and its predecessor agencies over the last ninety years. Pilots and other operational personnel must obtain certificates from the FAA, available only after extended periods of training intended to assure high skill levels and good judgment, as well as to protect against the possibility that a pilot might drop dead at the controls.[43] The aircraft cannot be flown until they receive airworthiness certificates. These certificates are the end result of an arduous, multi-year, multi-million dollar process that examines each component. Fasteners holding the skin to the frame[44] must meet regulatory requirements. Rules address the ability of a pilot to use his fingertips to manipulate moving maps during turbulence.[45] They require flight tests to determine to the feasibility of a reasonably skilled pilot to land safely if one or more engines quit.[46]

Even when the aircraft is properly certificated and its pilot or pilots are validly licensed and meet currency-of-experience requirements,[47] there are still detailed flight rules to promote safe flight. The rules prohibit flight in really bad weather unless under the supervision of an Instrument Flight Rules ("IFR") clearance from FAA air traffic controllers, backed up by radar imagery and automatic collision avoidance telemetry.[48] In good weather, the

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43. 14 C.F.R. § 61 (specifying pilot certification requirements).

44. *See* 14 C.F.R. § 21.9(a)(3) (stating that nuts and bolts must be manufactured in compliance with regulations or industry specifications).

45. *See* FAA, AC 20-175, Controls for Flight Deck Systems Document Information (Dec. 8, 2011), *available at* https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019692 (rules for touch screens).

46. *See* 14 C.F.R. § 23.71 (requiring determination of maximum achievable glide distance for single-engine airplane after engine failure).

47. 14 C.F.R. § 61.57 (imposing recent flight experience requirements).

48. 14 C.F.R. § 91.155.

rules are less restrictive, but important ones include: prescribed altitudes, airport traffic patterns, and communication with FAA air traffic controllers in busy airspace.[49] In addition, they include detailed procedures for handling emergencies. See 14 C.F.R. §§ 91.123 (authorizing pilot to deviate from ATC instructions in emergency); 91.185 (specifying procedures for IFR operations if radio communications fail).

Although drones present the same basic risks as manned aircraft, they do not fit into this system very well. Since aviation regulation began with the enactment of the Air Commerce Act in 1926,[50] the central premise has been that a "pilot in command" would be aboard the aircraft, with ultimate responsibility for controlling it so that it complies with the rules.[51]

But drones do not have pilots, in this sense. Their operators are on the ground, flying the drones by a combination of remote control and autonomous maneuvers built in to the drone's onboard computers. This separation of operator and aircraft poses two risks not present with manned aircraft.[52] First, the DROP might lose the wireless control link. Second, he does not have the same visual, aural, and kinesthetic sensory inputs available to a pilot in the cockpit. The second risk is particularly important because of the emphasis on "see and avoid"[53] as the dominant philosophy for collision avoidance under the current regulatory regime.[54]

Moreover, many current requirements for aircraft, pilots, and flight are aimed at protecting the people aboard the aircraft, or at least the pilot when he is flying solo. Drones do not carry people, and so design constraints aimed at assuring visibility, seat restraints during turbulence, and crashworthiness to protect occupants are irrelevant to drone regulation.[55]

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49. *Id.*

50. Air Commerce Act of 1926, Pub. L. No. 254, 44 Stat. 568 (1926).

51. *See, e.g.*, 14 C.F.R. § 91.3 (current expression of pilot-in-command responsibility).

52. NPRM, *supra* note 7, at 20-21 (identifying two main risks).

53. The principle places primary responsibility on the pilot to avoid mid-air collisions by making visual contact with other aircraft and avoiding them.

54. NPRM, *supra* note 7, at 20 (characterizing see-and-avoid as a fundamental principle of collision avoidance); Kurt Colvin, et al., NASA Ames Research Center, IS PILOTS' VISUAL SCANNING ADEQUATE TO AVOID MID-AIR COLLISIONS? 1 (2005), *available at* http://humansystems.arc.nasa.gov/flightcognition/Publications/Colvin_ISAP05.pdf (noting centrality of "see and avoid" concept).

55. *See* NPRM, *supra* note 7, at 100 (noting that the dominant purpose of the flight-proficiency-demonstration and aeronautical experience requirements for

As such, it does not make sense simply to apply existing FAA rules to drones. The NPRM recognizes that traditional pilot certification requirements have limited relevance to microdrone operations[56] and that traditional airworthiness certification would impose costs disproportional to the risks.[57] New risks require new approaches, and risks that are no longer present do not need to be protected against.

C. Risks to vested interests

Regulatory strategies for microdrones are being shaped by economic as well as safety interests. Economic interests invested in the status quo often have retarded technological innovation.[58] Microdrone innovation will be no exception to this pattern.

As drone technology matures and is commercialized, and as machodrones become cheaper, the demand for certain types of helicopter services will diminish significantly. The FAA economic analysis of the NPRM includes in its cost-and-benefit analysis the assumption that a substantial number of helicopter jobs will be replaced by microdrones.[59] Commercial pilots already are urging the FAA to limit the competition from microdrones.[60] The helicopter market segments most at risk are those that do not involve carriage of passengers – operators that make movies, collect other aerial photography, and some newsgathering missions; inspection of bridges and power lines.[61] This market threat gradually will extend into logistics functions, as local delivery of Amazon packages becomes a more realistic possibility.[62]

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conventional pilots, protecting people on board the aircraft, does not apply to microdrones).

56. *Id.* at 97.

57. *Id.* at 137-38 (explaining why airworthiness certification is unnecessary).

58. James Bessen, *The Anti-Innovators: How Special Interests Undermine Entrepreneurship*, 94 FOREIGN AFF., Jan.–Feb. 2015, at 55, *available at* http://www.foreignaffairs.com/articles/142497/james-bessen/the-anti-innovators (arguing that government procurement processes, expansive assertion of intellectual property, and legislative initiatives to limit operations to certain licensed professionals are common tools to thwart entrepreneurship).

59. *See* George Thurston, FAA Office of Aviation Policy and Plans, Economic Analysis Division, Notice of Proposed Rulemaking Regulatory Evaluation at 23-26 (Feb. 2015), http://diydrones.com/profiles/blogs/faa-notice-of-proposed-rule-making-regulatory-evaluation.

60. *See* Nicas, *supra* note 8 (quoting commercial pilots worried about losing business to microdrones).

61. *See* OMB Analysis.

62. *See* Jonathan Berr, *Why Amazon's drone delivery service is a long way away*, CBS NEWS (Dec. 9, 2014, 4:35 PM) http://www.cbsnews.com/news/why-

On the other hand, passenger-carrying operations by both helicopters and fixed-wing aircraft will be little affected over the foreseeable future. Moreover, helicopter jobs cannot be threatened when they do not exist; helicopters do not deliver packages to ordinary homes and offices, although DHL has begun experimenting with helicopter delivery of high value medical and financial supplies and documents in congested urban areas.[63]

Traditional aviation's view of microdrones will crystallize as drone use becomes even more visible and decisions whether to use them migrate into the core of business strategy determination. As purchasers of helicopter services are confronted with decisions about further investment in helicopter support, whether in conjunction with in-house operation, or in conjunction with renewal or modification of contracts with helicopter contractors, some in the decisional process are saying, "Have we thought about using drones instead?"[64] That discussion will, in most enterprises, trigger an analysis of whether drones should be substituted for manned helicopters, in whole or in part. Helicopter operators will eventually embrace a strategy in which they offer a combination of helicopter and microdrone services.

The idea that a pilot in the aircraft is inherently safer than a drone may exaggerate reality. While it is assuredly true that a skilled, proficient pilot can handle unexpected, and therefore un-programmable, situations better than an automation system that has not been programmed to deal with it, most pilots are merely average. Further, the proficiency of an average pilot is declining with greater dependence on cockpit automation.[65] Pilots also make mistakes and introduce safety risks simply because they are in the cockpit: "Though the accident rate had been reduced, the accidents that

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amazons-drone-delivery-service-is-a-long-ways-away/ (reporting Amazon's domestic and foreign testing efforts).

63. Press Release, DHL Global, DHL dodges traffic with Los Angeles helicopter service (May 5, 2014), http://www.dhl.com/en/press/releases/releases_2014/express/dhl_dodges_traffic_with_los_angeles_helicopter_service.html (announcing DHL helicopter delivery in Los Angeles).

64. The co-authors have participated in such discussion with purchasers of helicopter services and those that provide them.

65. Antonio Puentes, The Manual Flight Skill of Airline Pilots (2011) (unpublished Master's thesis, San Jose State University), (on file with SJSU ScholarWorks, San Jose State University at http://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=5108&context=etd_theses) (marshalling evidence that manual flying skills of pilots have declined with the growth of cockpit automation); William Langewiesche, *The Human Factor*, VANITY FAIR (Oct. 2014), http://www.vanityfair.com/news/business/2014/10/air-france-flight-447-crash (arguing that pilot skills have declined as a result of relying on cockpit automation).

continued to occur were being caused almost entirely by pilots . . . ."[66] "The pilots' ability to make complex cognitive decisions—what Casner calls their 'manual thinking' skills—had suffered a palpable hit."[67]

Three influential aviation interest groups that have been most outspoken in their opposition to drones in their advocacy of stringent regulations are the Air Line Pilots Association ("ALPA"), the Aircraft Owners and Pilots Association ("AOPA"),[68] and the National Agricultural Aviation Association.[69] While crop duster jobs are threatened by drones, it is hard to see how airline pilot jobs are threatened, and the opposition may be genuine reflections of safety concerns, reinforced initially by instinctive job concerns. But the solution is not to require that DROPs be pilots. The skill set is different, to a significant degree.

As the debate continues, moderation of pilot opposition is likely. In any event, the helicopter industry already is embracing the opportunity to complement its service offerings. Matt Zaccaro, the president of Helicopters Association International ("HAI"), has encouraged the embrace: "Who better to operate vertical lift UAVs in a low altitude environment — conducting missions they already perform — than helicopter operators?"[70]

D. Regulatory status

On February 15, 2015, the FAA issued a NPRM to provide a general regulatory framework for commercial operation of microdrones. The following subsections provide the background for the NPRM and then summarize the contents of the NPRM itself.

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66. Langewiesche, *supra* note 65 (detailing series of pilot mistakes that led to crash of Air France Flight 447).

67. Maria Konnikova, *The Hazards of Going on Autopilot*, THE NEW YORKER (Sept. 4, 2014), http://www.newyorker.com/science/maria-konnikova/hazards-automation (reviewing research showing how automation produces boredom, complacency, and atrophy of pilot skills).

68. *See* Douglas Trudeau, Realtor, FAA Exemption No. 11138, Regulatory Docket No. FAA-2014-0481, 8-11 (Grant of Exemption Jan. 5, 2015), https://www.faa.gov/uas/legislative_programs/section_333/333_authorizations/media/Video_Solutions_LLC_11189.pdf (summarizing ALPA and AOPA opposition to proposed microdrone operation).

69. *Protecting Ag Pilots from the Threat of UAVs*, NAT'L AGRIC. AVIATION ASS'N, http://www.agaviation.org/protectingagainstuav (last visited Apr. 20, 2015, 10:31 PM).

70. Matt Zuccaro, *What Does the Future Hold?*, VERTICAL, Feb.-Mar., 2015 at p.12, http://www.verticalmag.com/digital_issue/2015/v14i1/files/2.html, quoted in Perritt and Sprague, *Reining in the Renegades*, *supra* note 21, at 8.

1. Background of NPRM

In the FAA Modernization and Reform Act of 2012,[71] Congress required the FAA to "develop a comprehensive plan to safely accelerate the integration of civil unmanned aircraft systems into the national airspace system," by November 10, 2012,[72] and to publish a five-year "roadmap," by February 14, 2013.[73] Specific provisions[74] require that the plan must provide for the integration of drones into the national airspace system no later than September 30, 2015,[75] promulgate a final rule to permit operation of microdrones by eighteen months after release of the comprehensive plan, and to publish a notice of proposed rulemaking ("NPRM") for implementation of the plan by the same date, with a final rule to be effective no later than sixteen months after release of the NPRM.[76]

The FAA released its comprehensive plan on November 6, 2013,[77] one year late, and its roadmap on November 7, 2013,[78] nine months late. The final rule for microdrones and the broader NPRM thus are due by May 2015, and a comprehensive final rule is due by September 2016. The FAA released an NPRM for microdrones on February 15, 2015. The public is entitled to comment for a period of 60 days. Promulgation of a final rule is unlikely before 2016 or 2017. In a variety of informal presentations, senior FAA officials have said that comprehensive drone regulation will not exist until 2020, at the earliest.[79] The NPRM charts new territory, and many issues are unresolved.

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71. FAA Modernization and Reform Act of 2012, Pub. L. No. 112-95, 126 Stat. 11 (Feb. 14, 2012).

72. FAA Modernization and Reform Act, § 332(a)(1) (2012) (requiring plan by 270 days from the date of enactment).

73. *Id.* at § 332(a)(5).

74. *See id.* at §§ 331-336.

75. *Id.* at § 332(a)(3).

76. *Id.* at § 332(b)).

77. UNMANNED AIRCRAFT SYSTEMS (UAS) COMPREHENSIVE PLAN (Sept. 2013), *available at* https://www.faa.gov/about/office_org/headquarters_offices/agi/reports/media/UAS_Comprehensive_Plan.pdf.

78. INTEGRATION OF CIVIL UNMANNED AIRCRAFT SYSTEMS (UAS) IN THE NATIONAL AIRSPACE SYSTEM (NAS) ROADMAP (2013), *available at* https://www.faa.gov/uas/legislative_programs/uas_roadmap/media/UAS_Roadmap_2013.pdf.

79. Scott Shackford, *FAA: Drone Regulations Are Vital to Protecting Safety, and You'll Get Them in a Decade or So*, REASON (May 13, 2014, 11:28 AM), http://reason.com/blog/2014/05/13/faa-drone-regulations-are-vital-to-prote (quoting Jim Williams, head of FAA's unmanned aircraft office).

In the meantime, the FAA prohibits commercial flight of drones unless civilian operators obtain an exemption under section 333 of the 2012 Act or an experimental airworthiness certificate[80] and a certificate of waiver and authority ("COA"), both of which limit operations to specific vehicles and specific geographic areas. Civilian operators are only permitted experimentation, demonstration, and training operations under experimental airworthiness certificates.[81] Some 189 section 333 exemptions have been granted, all of which impose stricter requirements than those proposed in the NPRM.[82]

The agency's slow pace in developing a regulatory framework for drones has been under attack. On March 6, 2014, an administrative law judge ("ALJ") at the National Transportation Board ("NTSB")[83] invalidated a $10,000 penalty levied against Raphael Pirker[84] by the FAA for commercial operation of a microdrone and held that the FAA's prohibition on commercial operations was invalid because it irrationally distinguishes between commercial operations and recreational or hobbyist operations of the same vehicle.[85] The ALJ decision was reversed by the full NTSB later in the year,[86] but the litigation showcased the regulatory uncertainty and the contending positions of drone proponents and the FAA. Press and media organizations filed an amicus brief in the *Pirker* case, arguing that the current prohibition on news gathering operations of microdrones violates the First Amendment of the United States Constitution.[87] Most aviation advocacy organizations joined in a letter to the FAA administrator urging him to accelerate

80. *See Unmanned Aircraft Systems*, FAA (Mar. 12, 2015, 3:12:12 PM), https://www.faa.gov/uas/ (summarizing types of authorization for UAS use).

81. *Unmanned Aircraft Systems Frequently Asked Questions*, FAA (Jul. 15, 2014, 11:58:16 AM), https://www.faa.gov/uas/faq/#qn4.

82. *Section 333*, FAA (Apr. 14, 2015, 9:07:01 AM), https://www.faa.gov/uas/legislative_programs/section_333/.

83. The NTSB hears appeals of FAA civil penalties.

84. Mr. Pirker was taking photographs of the University of Virginia by microdrone.

85. Raphael Pirker, Decisional Order, Docket CP-217 (Mar. 6, 2014).

86. Raphael Pirker, Order No. EA-5730 (N.T.S.B.), Docket CP-217 (Nov. 17, 2014).

87. *American News Media Coalition Files Brief in Support of Pirker, First Amendment Rights*, PROF. SOC'Y OF DRONE JOURNALISTS (May 7, 2014), http://www.dronejournalism.org/news/2014/5/american-news-media-coalition-files-brief-in-support-of-pirker-first-amendment-rights.

release of an NPRM and to allow greater flexibility in the meantime.[88]

The agency tried to relieve pressure for issuance of the overdue NPRM by granting a handful of petitions for exemption from the prohibition.[89] In all of these grants the FAA insisted on requiring at least a private pilot airman certificate for the operator and has also insisted on the presence of an observer as well as the pilot-operator. This requirement makes little sense, because of the divergence between the skills needed to fly a manned airplane or helicopter and those needed to fly a microdrone safely.[90]

A major drone advocacy group and several of the petitioners proposed a more sensible requirement: that DROPs pass a written test on basic aerodynamics, airspace regulation, weather, and aviation safety. For example:

> No person may operate a micro unmanned aircraft system under this part without first passing the FAA private pilot written airman knowledge test administered by an FAA-accredited pilot school or test center. Prior to any operation under this part, the operator shall send written notification to the FAA evidencing the test results together with the operator's name and contact information, which upon submission the Administrator will acknowledge in writing as

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88. Letter from Michael Toscano, President & CEO of the Association for Unmanned Vehicle Systems International, to Michael Huerta, FAA Administrator, (Apr. 8, 2014), *available at* http://higherlogicdownload.s3.amazonaws.com/AUVSI/958c920a-7f9b-4ad2-9807-f9a4e95d1ef1/UploadedFiles/Joint%20Letter%20to%20FAA%20on%20Expediting%20UAS%20rulemaking%20Final.pdf.

89. By the time the NLRM issued, the agency had granted twenty-five out of nearly 400 pending applications for exemption.

90. The difference in skills requirements are considered in greater depth in § 2. For example, one may not be certificated as a private pilot unless she receives flight instruction, a CFI signoff, and passes a flight test demonstrating, among other things, slow flight and stalls, basic instrument maneuvers, night operations, and emergency procedures. *See* 14 C.F.R. § 61.103(d) (requiring instructor endorsement); § 61.103(h) (requiring flight test); 14 C.F.R. § 61.107 (enumerating areas as to which flight proficiency must be demonstrated). Multirotor microdrones do not stall. The techniques required for slow flight are completely different in airplanes than in microdrones. The principal emergency for which helicopter pilots train is an engine failure followed by an autorotation. Multirotor microdrones are incapable of autorotative flight, because their rotors have fixed pitch.

On the other hand, safe operation of a microdrone requires maintenance of the wireless control link, and proficiency with autonomous features such as return-to-home, matters that are not covered in private pilot training.

constituting the operator's micro unmanned aircraft pilot certificate for purposes of 49 USC §44711.[91]

This proposal is better than the FAA's insistence on a private pilot's license, although much of the private pilot knowledge test[92] is irrelevant to microdrone operation, such as meteorology, long-distance flight planning and navigation, stall and spin recognition and recovery, runway lengths, and takeoff and landing distances.

Several other requirements are rational and desirable, such as requiring DROPs to complete certain training in which they demonstrate proficiency in flying microdrones, or requiring some contact between a potential DROP and a certificated flight instructor, who could assess psychological suitability and potential for involvement with terrorism.[93]

As high-capability microdrones at prices in the low thousands of dollars proliferated in the marketplace, a growing number of operators did not wait for the FAA. For example Epic Aerial,[94] a Chicago-area commercial microdrone operator, offers aerial photography for advertising, residential, commercial, special event, construction, transportation, zoning, agriculture, and farming. Epic Aerial claims that they "operate under the jurisdiction of the United States Of America National Transportation Safety Board Office of Administrative Law Judges [sic] ruling of FAA v. Raphael Pirker . . . ."[95]

2. Content of the NPRM

The NPRM, if it becomes final, will eliminate many of these objections and weaken the tendency toward noncompliance. The NPRM proposes creating a new Part 107 to title 14 of the Code of

91. UAS America Fund, *Unmanned Aerial Systems: A Path Forward* (Dec. 18, 2014), http://www.uasamericafund.com/assets/uasfund_mua-proposed-part107_dec2014.pdf.

92. 14 C.F.R. § 61.105 (specifying knowledge requirements).

93. *See* FAA, *Aviation Instructor's Handbook* (2008), 1-9 (asserting that flight instructor has duty to assure that a student with serious psychological abnormality "does not continue flight training or become certificated as a pilot").

94. Epic Aerial, *FAQ*, EPIC AERIAL PHOTO, http://www.epicaerialphoto.com/#!about/c1l5m (last visited May. 28, 2015) (advertising, residential, commercial, special event, construction, transportation, zoning, agriculture, and farming aerial photography services). As of Feb. 13, 2015, Epic Aerial continued to advertise its services on the Web, and no reports of adverse FAA action can be found.

95. *Id.*

Federal Regulations.[96] The NPRM relaxes some of the less rational restrictions imposed in the section 333 exemption grants. It eliminates the private-pilot certificate requirement and the requirement for a separate operator. It establishes a straightforward written test requirement for DROPs, requires them to have contact with a flight instructor to identify any national security risks,[97] and allows them to self-certify physical condition and competence to fly the intended microdrone. As expected, it limits flights to line of sight of the DROP, no more than 500 feet above ground level, daytime only. It requires registration of each microdrone and display of the registration number.[98]

The proposed rule does not apply to public aircraft operations (those of governments such as law-enforcement and intelligence agencies). But the NPRM notes that public-use agencies could declare their microdrone operations to be "civil" and thus bring them within the NPRM.[99]

Under the Administrative Procedure Act[100] any member of the public is entitled to at least 30 days to comment on the proposal rules—the NPRM allows 60 days.[101] Based on submissions on section 333 exemption petitions and the politics of vested interests, considered in § C, pilots groups are likely to press for a toughening of the restrictions, while drone advocacy groups press for a weakening, particularly for very small drones.

III. MICRODRONES REQUIRE A DIFFERENT REGULATORY STRATEGY

A. *Unsuitability of traditional regulation for microdrones*

As the NPRM recognizes, extending traditional airworthiness requirements for microdrone aircraft,[102] insisting on manned-aircraft pilot certification, and subjecting microdrones to rules designed for airplanes and helicopters will not protect the public or the aviation community. Rules do not advance the public interest unless they change behavior. Non-compliant drone activities

96. FAA, Notice of Proposed Rulemaking: Operation and Certification of Small Unmanned Aircraft Systems, RIN 2120-AJ60, Docket No. FAA-2015-0150, 38.

97. *Id.* at 118-122 (describing TSA vetting and identity verification by flight schools and CFIs).

98. *Id.* at 128 (explaining registration number requirement).

99. NPRM, *supra* note 7, at 45.

100. Administrative Procedure Act, 5 U.S.C. § 55.

101. *Id.* at § 553(d).

102. The NPRM preamble explicitly disclaims the necessity for airworthiness certification of microdrones. NPRM, *supra* note 7, at 15.

are too hard to detect, no community of DROPs exists to replicate the social forces that keep pilots safe, and the FAA does not have the resources to police every backyard and park.

The Federal Aviation Act provides for civil penalties of up to $25,000 against "persons" for violating Federal Aviation Regulations.[103] The Act also provides for criminal penalties against an individual for operating or attempting to serve as an airman without a pilot's license,[104] against a “person” who knowingly operates an unregistered aircraft,[105] and against a "person" who knowingly violates national defense airspace.[106] The use of the word “person” in these rules indicates that they apply to anyone, not just pilots and FAA-approved operators. But these penalties are weak deterrents if the probability of detection and imposition of sanctions is small.

Government regulation reduces risk only when there is a certain degree of compliance. Few regulatory regimes result in 100% compliance, but thoughtful regulators are attentive to formal and informal compliance incentives and enforcement tools. If those regulated have a few incentives to comply with regulatory limitations, strong incentives to ignore them, and if enforcers are likely to be overwhelmed by the number and the scope of violations, the regulatory approach is wrongheaded and will be ineffective.

Traditional aviation regulation depends upon the validity of several rarely articulated premises:

1. *Aircraft* subject to the regulations are expensive, creating an incentive to keep them legal to fly, in good working order, and maintained to enhance their resale value.

2. *Pilots and mechanics* invest tens of thousands of dollars in earning their ratings; they avoid behaviors that would risk loss of their flying or other professional privileges.

3. *Violations of the FARs* are relatively easy to detect. Aircraft are large and noisy and operate from a limited number of aerodromes. If an airplane or helicopter flies recklessly or otherwise violates flight rules, someone is likely to notice it. The comprehensiveness of air-traffic control radar surveillance and other techniques for

103. 49 U.S.C. § 46301(a) (2014).
104. 49 U.S.C. § 46317 (2000).
105. 49 U.S.C. § 46306(b)(6) (1996).
106. 49 U.S.C. § 46307 (1994).

> tracking aircraft make it relatively easy to trace a particular aircraft to a point of landing.[107]

The first two premises lead to a culture of compliance in the aviation community.[108] The third makes it relatively easy for the FAA to catch those members of the community who stray.

These premises do not apply to the world of microdrones. Microdrones are relatively inexpensive and are likely to be viewed by their purchasers as more or less disposable once the novelty of flying them wears off, once new technologies have made replacements more attractive, or when some kind of mishap destroys them or causes their loss. An owner's attitude toward a $500–$1500 consumer item, like a microdrone, is completely different from an owner's attitude toward a $250,000 durable asset like a Robinson R22 helicopter.

1. Difficulty of detection

Microdrones can be operated from anywhere. Detecting one that is being flown in somebody's backyard in violation of FAA rules is nearly impossible. Hobbyist and recreational use is not regulated anyway, and it would be difficult for casual observation to determine if the purpose of a particular activity is commercial. The same microdrones can be flown for recreational and hobby purposes or for commercial purposes.

Enforcement of the FAA ban on commercial drone flights depends upon detecting commercial activities and identifying them as such. This is not difficult if an enterprise holds itself out as a commercial operator and solicits customers. This is the prevailing practice for manned aircraft, because their high acquisition and operating costs, and the skills needed to fly them, mean that only larger organizations can afford to own aircraft; most of them contract with operators who serve multiple customers. The business models of the operators require them to be visible.

This is not the case with microdrones. The advertising and promotional budget of almost any realtor permits it to buy a couple of microdrones to take photographs and video of its properties to attract potential buyers. Almost any police department can afford one. TV stations can buy 500 of them for the cost of one ENG truck. Even small farmers can afford one. Using microdrones for their own

107. These premises are original to the co-authors, based on their combined fifty-five years' involvement with the aviation community.

108. See § 2 for an analysis of cultures of compliance.

core business activities is "commercial," but it does not involve any advertising or holding out to the public. In other words, the use basically will be invisible.

The limited operating radius of microdrones also makes them hard to detect. Most manned aircraft missions require transit by the aircraft of distances of many miles. Obviously, this is true of scheduled cross-country airline, air taxi flight, or executive jet operations. But it is also true of short-range missions, including power line and pipeline patrol, airborne newsgathering, rides, and tours. An airplane takes off from an airport, flies its mission, and lands at an airport. A helicopter does the same thing from an airport or heliport. Anyone in the vicinity can see them and, at least roughly, what they are doing.

This is not true for a microdrone taking off from a farmer's forty-acre field and flying a grid over the field at 300 feet to photograph crop growth patterns. It is not true of a microdrone launched by a realtor in the front yard of an upscale property framed by trees to take pictures of the swimming pool, while remaining aloft for only ten to fifteen minutes.

When mobilizing armies of inspectors to ferret out violations is infeasible, as it would be with commercial microdrones, the content of regulations must be molded to increase the likelihood of voluntary compliance.

2. Microdrone operators are not part of the aviation community's culture of compliance

Rule compliance is more likely when cultural norms align with the law. This occurs in some well-defined communities; it also occurs in society writ large. Strong psychological and sociological phenomena shape the environment that needs to be regulated. As microdrones proliferate, the question will be whether, as in traditional aviation, sociological forces will reinforce or undermine formal regulation.

Assessing the opposing possibilities requires considering norm theory from the field of sociology, identifying the features of compliance norms in the traditional aviation community, and considering how the world of microdrone operations may be different.

a. Norm theory

Communities exist in which members almost always comply with a set of behavioral rules that are not codified in the formal law.

Diamond traders,[109] participants in the Hawala financial exchange system,[110] ranchers in some parts of the West,[111] and traditional model aircraft hobbyists[112] adhere to a "rule of law" that is not expressed in codified law, but rather in a complex set of community rules or "norms."

In these examples, compliance occurs within a tightly knit community in which the members are interdependent on a variety of interests important to them. In each, members are bound together by reciprocity. Ranchers share resources; model aircraft builders and operators share ideas. A member who breaks the rules risks the loss of the hallmarks of membership, which may be important in economic terms, as in ranching, or on more social terms, as in the model aircraft community.

In other contexts beyond these tightly knit communities, however, compliance is high despite the absence of close social or economic ties. Most members of the general public adhere to informal norms in certain situations. Going to the back of the line is a clear example[113] though honored more faithfully in the United States, Canada, and England than it is, say, in Germany or China.[114]

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109. *See generally* Pammela Quinn Saunders, *A Sea Change Off the Coast of Maine: Common Pool Resources as Cultural Property*, 60 EMORY L.J. 1323, 1351 (2011) ("Effective Self-Regulation by 'Close-Knit' Groups," citing authority on self-regulation by diamond traders); David V. Snyder, *Private Lawmaking*, 64 OHIO ST. L.J. 371, 402 (2003) (discussing diamond trading as the most "picturesque" example of self-regulation).

110. *See* Rachana Pathak, *The Obstacles to Regulating the Hawala: A Cultural Norm or a Terrorist Hotbed?*, 27 FORDHAM INT'L L.J. 2007 (2004) (describing history and functioning of Hawala system).

111. *See* ROBERT C. ELLICKSON, ORDER WITHOUT LAW 52-64 (1991) (explaining social dynamics of enforcing private norms for cattle ranchers).

112. Compliance with informal guidelines for model aircraft flight seems to be breaking down – or perhaps noncompliance simply has become more visible.

113. *See* Bernd H. Schmitt, et al. *Intrusions into waiting lines: Does the queue constitute a social system?*, 63 J. PERSONALITY AND SOC. PSYCH. 806-815 (Nov. 1992) (reviewing experiments on breaking into line; concluding that queuing is example of social system); Hannah Minton, *Waiting and queuing in the check-in hall: An ethnographic study of queuing and waiting for check-in services at Manchester Airport*, J. AIRPORT MGT. (Apr. 1, 2008) (reporting observations of queuing at British airport; analyzing its characteristics as social system).

114. Linton Weeks, *Pumps And Polls: Why Americans Wait In Lines*, NPR (Oct. 29, 2012), http://www.npr.org/2012/10/29/163859900/pumps-and-polls-why-americans-wait-in-lines (commenting that queuing predominates in Britain, and is weak in Germany and China, among other places); Tristin Hopper, *Everyone line up: Canada's tradition of orderly queuing 'foreign and strange' to many newcomers*, NAT'L POST (Jul. 25, 2014), http://news.nationalpost.com/2014/07/25/everyone-line-up-canadas-tradition-of-orderly-queuing-foreign-and-strange-

The literature on norm theory probes the circumstances that lead toward or away from compliance with norms of behavior, including official legal rules but going far beyond that.[115] Literature on these patterns of behavior provide a fertile source for understanding what is likely to promote or undermine compliance with limitations on microdrone use.

The following variables affect compliance:[116]

1. *Legitimacy.*[117] Actors are more likely to comply with a norm they perceive to be legitimate. Legitimacy in this context means, rather than political legitimacy, reasonableness in light of the interests of the actor. Legitimacy also is higher if the rule seems consensual and widely respected rather than being imposed from outside.

2. *Cost of compliance.* [118] Economists consider rule compliance to be the result of the straightforward calculation of the net benefits of complying or not complying.[119] As the other four factors show, however, determinants of compliance are more varied and less tangible than a simple economic model.

   Still, one is more likely to comply with a rule that imposes few costs, economically, [120] and psychologically. One

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to-many-newcomers/ (last updated Jan. 24, 2015, 9:51 PM) (observing that custom among English-speaking peoples to stand in line is foreign to other cultures).

115. *See* ELLICKSON, *supra* note 111.

116. *See generally* K. Kuperan & Jon C. Sutinen, *Blue Water Crime: Deterrence, Legitimacy, and Compliance in Fisheries*, 32 LAW & SOC'Y REV. 309 (1998) (empirical analysis of compliance by fishermen with fishing laws); Health and Safety Executive, *The determinants of compliance with laws and regulations with special reference to health and safety* (2008), http://www.hse.gov.uk/research/rrpdf/rr638.pdf [hereinafter "HSE Report"].

117. *See* HSE Report, *supra* note 116, at 21 (discussing how self-regulatory approaches increase legitimacy and therefore compliance) Kuperan and Sutinen separate this consideration into two factors: the more legitimate the regulation as perceived by the individual, and the more legitimate the regulation as perceived by the community at large." Kuperan & Sutinen, *supra* note 116, at 314.

118. *See* HSE Report, *supra* note 116, at 17 (observing that business compliance is influenced by the costs of compliance).

119. Alternatively, the same concept can be expressed in terms of the net costs of compliance.

120. The costs that matter are the expected costs: the probability of a sanction being assessed after detection, multiplied by the magnitude of the sanction. As section 1 explains, the probability of detection and imposition of penalties for noncompliant microdrone flight is low. Federal Aviation Regulation, *Law*

also is more likely to comply if the costs of non-compliance are high. Driving on the wrong side of the road is no cheaper than driving with the current of traffic, but the cost of driving on the wrong side can be high if there is a head-on collision. In contrast, adhering to a low speed limit on a limited access highway imposes costs in terms of time to travel. The cost of non-compliance is the probability of getting a ticket multiplied by the amount of the fine.[121]

3. *Clarity of rule.*[122] One is more likely to comply with a rule that is specific and clear, because it is easier to determine the boundaries of acceptable conduct.

4. *Reciprocal benefits.*[123] One is more like to comply with a rule if she perceives that others in the community are complying as well, making everyone better off. The importance of reciprocity grows if compliance by others in the community benefits an individual actor, or, conversely, if non-compliance by others worsens a compliant actor's position.[124]

Enforcement Guidance for Suspected Unauthorized UAS Operations, http://www.faa.gov/uas/regulations_policies/media/FAA_UAS-PO_LEA_Guidance.pdf (explaining limitations on FAA enforcement of ban on commercial drone operations; identifying all the procedural and evidentiary barriers to imposing civil penalties on DROPs).

121. Kuperan and Sutinen subdivide the cost consideration into three factors: "(1) The higher the probability of detection and sanction (or the greater the enforcement inputs); (2) the greater the penalty if sanctioned; and (3) the less profitable violating is compared to complying . . . ." Kuperan & Sutinen, *supra* note 116, at 314.

122. *See* HSE Report, *supra* note 116, at 11 (observing that precise rules are easier to enforce and can promote compliance).

123. *See* Dan M. Kahan, *The Logic of Reciprocity: Trust, Collective Action, and Law*, (John M. Olin Center for Studies in Law, Econ., and Pub. Pol'y, Working Paper No. 281, 2002), http://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1007&context=lepp_papers (observing that reciprocity activates honor and altruism to comply with community norms). *See also* Kuperan, *supra* note 118, at 321-322 (nothing that "the social reputation of a fisherman is not as likely to be affected if he violates in a community in which a large proportion of the fishermen is violating").

124. Kuperan & Sutinen, *supra* note 116, at 321-322 (noting that if a large proportion of fishermen violate a regulation, nonviolators lose out to violators in competition for resources).

5. *Reputation and self-esteem.*[125] Reputation and self-esteem depend on the values to which an individual and those with whom he interacts have been socialized. Socialization is the process through which an individual takes on the values of a group and judges her own conduct by those values.

Individuals, especially members of an identifiable profession or craft, want to think of themselves as being "professional," and this usually means complying with the norms of the occupation. It is also true, however, that individuals are members of different groups—families, political parties, professions or crafts, clubs—and the impact of particular conduct on their self-esteem and reputations may conflict depending on which tie is most salient.[126] Business entities perceive that they have an advantage in the marketplace if their customers perceive them as law-abiding.

The determinants are interrelated. The effect of noncompliance on reputation and esteem, for example, depends on perceived legitimacy.[127] Actors are more likely to comply with a rule that does not cost them too much and when it is likely to benefit them if others comply.

The "war on drugs" represents dramatic regulatory failure. As such, it also illustrates the operation of the factors identified in this section. The rules are simple: you can't possess or use banned substances. Reciprocal compliance is largely irrelevant: if one smokes pot, it does not much matter whether others do or not (apart from the group sociology, part of factor number (5). Enormous detection and enforcement resources are deployed at every level of government and yet compliance is low.[128] Part of the problem is that the magnitude of noncompliance overwhelms any conceivable level of enforcement resources. Recreational drug users assess the likelihood of getting caught with occasional marijuana use to be low, and pot use therefore represents a tolerable risk.

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125. *See* HSE Report, *supra* note 116, at 21 (discussing reputation as a determinant of compliance). Kuperan and Sutinen identify this as stemming from "the higher moral development of the individual." Kuperan & Sutinen, *supra* note 118, at 314.

126. *See* Cassandra Burke Robertson, *Organizational Management of Conflicting Professional Identities*, 43 CASE W. RES. J. INT'L L. 603, 605 (2011) (arguing that alleged professional lapses by military personnel, physicians, psychologists, and lawyers in counter-terrorism campaigns arise from conflicting identification with different professional and organizational norms).

127. Kuperan & Sutinen, *supra* note 116, at 329.

128. *See* note 131, *infra*.

Most important is that a critical mass of the target population does not believe the prohibitions are legitimate, at least as they apply to recreational drugs like marijuana and cocaine, and thus there is no loss of self-esteem or reputational loss from noncompliance with the law.

> 'Prohibition,' the ban on the drug alcohol from 1919 to 1933 [and] . . . the 'War on Drugs,' the current campaign against a number of drugs, but especially cocaine, heroin, marijuana, and methamphetamine [are similar]. [B]oth failed or are failing to eliminate consumption of the targeted drug(s) while generating secondary costs that outweigh the problems caused by the drugs themselves, and both failed or are failing for the same reason: the futility of trying to eliminate, by fiat, flourishing markets for highly demanded goods.[129]

The five factors also suggest that non-compliance will be low if the FAA tries to impose traditional aircraft regulation on microdrones.

b. Culture of traditional aviation

Traditional aviation is a community. Captains of 787 transports, mechanics who work on news helicopters, and youngsters who just soloed in single-engine Cessnas, all perceive themselves as members of a community—a community that is important to their individual identity. Pilots routinely introduce themselves by saying, "I am a pilot," only later explaining whether they work for an airline, give flight instruction, or fly recreationally. The socialization process in aviation is robust.[130]

Aviators perceive FAA rules as legitimate. The patterns of learning to fly crystallized nearly a century ago before the advent of aviation regulation and now are codified in the FARs. The interaction between experience and rule content has been a hallmark of FAA regulation. Aviation interest groups petition for new regulation or changes in existing regulations. When the FAA

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129. Seth Harp, *Globalization of the U.S. Black Market: Prohibition, the War on Drugs, and the Case of Mexico*, 85 N.Y.U. L. REV. 1661, 1663-64 (2010).

130. *See* Bill D. Bell et al., *Aviation Safety as a Function of Pilot Experience: Rationale or Rationalization?*, 5 J. AVIATION/AEROSPACE EDUC. & RES. 2-3 (1995), *available at* http://commons.erau.edu/cgi/viewcontent.cgi?article=1154&context=jaaer (explaining theory of socialization and arguing that it is particularly effective in aviation; concluding that concrete measures of experience and rating have little predictive power for safe operation).

contemplates rulemaking, it consults elaborately with a network of industry advisory committees. Members of the community participate in the notice and comment process for rulemaking. The result is a body of rules that aviators perceive as having resulted from their ideas and participation. Aviators and their interest groups may complain bitterly about intrusive, irrational FAA regulation, but they usually comply, even when they do not like it. The rules are the rules and to a considerable extent, aviators reason, they are *our* rules.

Fear reinforces the legitimacy of regulatory requirements in traditional aviation. The vast majority of pilots and would-be pilots do not want to get killed, and they don't want to kill people they know well enough to be their passengers. Most people who take flight instruction admit to being frightened at some points in the learning process—in the first few landings, on the first solo, or in the first helicopter autorotation. Good flight instructors know that part of their teaching job is to overcome fear by building student confidence that the aircraft is not going to fall out of the sky.[131] Teaching that complies with the FARs promotes safety reinforces the legitimacy of the rules.

Rules and self-preservation constantly reinforce each other. When a private pilot lands a Cessna 172, he keeps the approach speed five to ten knots above stall speed because the FARs require him to keep it at the speeds specified in the Pilot's Operating Handbook or Flight Manual *and* because he doesn't want to stall, crash the airplane, and get killed.[132]

The relative cost of compliance encourages aviators to follow the rules. Past technologies and the infrastructures for using them have characteristics that promote rule compliance. Manned airplanes and helicopters are expensive to buy and expensive to operate. The usual aircraft owner and operator has hundreds of thousands to millions of dollars invested in his aircraft; the typical pilot has tens to hundreds of thousands of dollars invested in his airman rating(s).[133] They do not want to put that investment at risk

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131. FAA, *supra* note 93, at 1-8 (assessing student fear as a barrier to learning).

132. *See* 14 C.F.R. § 91.9(a) (prohibiting operations in violation of limitations in required flight manual).

133. *See Pilot Certificate Options and Timeline*, AIRCRAFT OWNERS AND PILOTS ASS'N, http://www.aopa.org/letsgoflying/ready/time/options.html (last visited Mar. 30, 2015) (estimating cost of private pilot license as ranging from $5,000 to $9,000). *See also Helicopter Professional Pilot Programs Program Costs*, HILLSBORO AERO ACADEMY, http://www.flyhaa.com/en/page/helicopter_flight_training_program_costs (last visited Mar. 30, 2015) (estimating total program cost for private, commercial, instrument, and flight-instructor ratings as $64,322), and *Tuition and Estimated Costs*, EMBRY-RIDDLE AERO. U.,

by violating the rules. For members of the aviation community, actions to suspend, modify, or revoke their pilot or operator certificates are simpler then actions to collect civil penalties from non-aviator DROPs. This ratchets up the expected cost of an enforcement action.

Moreover aviators perceive the likelihood of detection as high. They think that they are more likely to get caught in rule violations than they probably are, objectively.[134] Most pilots believe that if they intrude into certain types of airspace without a clearance, they will be tracked on radar and apprehended when they land.[135] Most pilots and operators perceive the likelihood of a "ramp inspection"[136] by an FAA inspector to be much higher than it is. The reality is that FAA inspectors drop in only a few times a year to inspect the operations at a particular airport.[137]

Aviators deal with clear rules. Most of the FARs are specific and clear: a pilot must fly at odd thousands of feet plus five-hundred feet when eastbound;[138] she must have certain documents in her possession when she flies;[139] she must have a clearance to penetrate Class B airspace.[140] While there are many rules, ground instruction and knowledge testing assure familiarity with them, and a check of the FAR/AIM book refreshes a pilot's recollection of the specific details.

Aviators benefit from reciprocity. The rules governing operations at airports without control towers are good examples of reciprocity in traditional aviation. If everyone flies a standard traffic pattern, each of them knows where potential collision hazards are. If all of them use the common traffic advisory frequency to broadcast

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http://daytonabeach.erau.edu/admissions/estimated-costs/index.html (last visited Mar. 30, 2015) (estimating costs for three year flight program at $33,000 to $48,000).

134. The factual assertions in this section are based on much "hangar talk" between the co-authors and other pilots.

135. The fear is not entirely fanciful. *See* Sturgell v. Blum, NTSB Order No. EA-5371, Docket SE-18012 (Feb. 29, 2008), *available at* http://www.ntsb.gov/legal/alj/OnODocuments/Aviation/5371.PDF (affirming penalty for entering Class B airspace without clearance).

136. *See* Federal Aviation Administration, Flight Standards Inspection Manual § 4 (Aug. 27, 2014), *available at* http://fsims.faa.gov/WDocs/8900.1/V06%20Surveillance/Chapter%2001/06_001_004.htm (FAA instructions on conducting ramp inspections).

137. *See* Bonanza36, *Ramp Checked!*, FLIGHTBLOG (Dec. 4, 2011), https://bonanza36.wordpress.com/2011/12/04/ramp-checked/ (pilot description of benign ramp check—first one in 18 years of flying).

138. 14 C.F.R. § 91.159 (2015).

139. 14 C.F.R. § 61.3 (2015).

140. 14 C.F.R. § 91.131 (2015).

their positions and intentions surprises and the risk of mid-air collisions is reduced further.

One is more like to comply with a rule if she perceives that others in the community are complying as well, making everyone better off. The importance of reciprocity grows if compliance by others in the community benefits an individual actor, or, conversely, if non-compliance by others worsens a compliant actor's position.[141]

Rule compliance reinforces aviator reputation and self-esteem. This is the most important factor that distinguishes traditional aviation from microdrone operations. Strong attachment to the aviation community strengthens the level of reputation and self-esteem when an aviator complies with the rules.

Members of a community sharing highly specialized skills have tighter attachment to the community. Flying and maintaining airplanes and helicopters require significant specialized skill. No ordinary person struck with the whim to fly believes that he could walk on the field, jump in an airplane, let alone a helicopter, take it off, keep straight and level and land it. No ordinary person would think he would know how to perform hundred-hour inspections on either aircraft. So in traditional aviation, an infrastructure exists to teach people how to become aviators.

Not only practical skills come out of the training infrastructure; a culture also emerges. In other words, flight instruction and other mechanisms of general aviation socialize as well as train. One of the first half-dozen things that happens when someone goes for an initial flight lesson is that he gets a copy of a thick book that contains the Federal Aviation Regulations and the Airman's Information Manual. Most students in any field get books at the beginning of a course, but the FAR/AIM book becomes a constant reference for flight and knowledge tutoring. From the first day, the point is made that there is a complex set of rules that are any pilot's companion.

Safe practices are part of the traditional aviation culture. In most organizational settings, including light-airplane recreational flying clubs as well as legacy-airline flight departments, safe practices, good judgment, and caution are reinforced by group approval. While various economic and psychological pressures continue to cause accidents, pilots perceived to be dangerous because of their

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141. Kuperan & Sutinen, *supra* note 116, at 321-322 (noting that if a large proportion of fishermen violate a regulation, non-violators lose out to violators in competition for resources).

low skill levels or their poor judgment are usually pariahs. They may kill someone else as well as themselves.[142]

All of these characteristics of the traditional aviation community enhance compliance with FAA rules.

c. Microdrones are different

Few of the forces that socialize aviators to a culture of compliance operate with respect to DROPs. There is no popular literature spanning 100 years about the romance of drone flying, as there are celebrating the romance of flying airplanes and helicopters. DROPs do not attend DROP flight schools and participate in hanger talk – there are no DROP schools. DROPs, for the foreseeable future are not likely to introduce themselves to a stranger as "DROPs," as opposed to photographers, realtors, photojournalists, or construction site supervisors.

Legitimacy. Because DROPs do not participate in a training infrastructure, they have no occasion to learn about FAA regulations. There is no reason they would have had any awareness or contact with the FAA—unlike an airplane or helicopter pilot who has been steeped in the role of the FAA. A DROP who familiarizes himself with the FARs is not likely to find much relevant to the microdrone flying he wants to do. If they are not relevant, why should he think of them as legitimate? Requiring a pilot's license that focuses on conditions that microdrones do not encounter and skills that DROPs do not need only makes the legitimacy problem worse.

Relative cost of compliance. One of the advantages of the NPRM is that it simplifies compliance. The OMB analysis estimates an average of $300 to comply. Compliance with the training and testing requirements, tailored as they are around specific drone characteristics, will, as OMB says, reduce risk and therefore cost. Compliance with tougher rules, such as the private pilot and observer requirements in the section 333 exemptions, requirements for elaborate maintenance and operating procedures documents and inspection by certificated mechanics would cost thousands dollars and do little to enhance safety. The worst that could happen if a DROP ignored such rules is a low probability that the FAA would commence an enforcement action against him. More likely he might crash the drone and have to spend $1,000 or so to get

142. *See* Manoj S. Patankar & Edward J. Sabin, *The Safety Culture Perspective*, *in* HUMAN FACTORS IN AVIATION 95, 109 (Eduardo Salas & Dan Maurino eds., 2d ed. 2010) (suggesting evaluating stories of peer pressure: what makes heroes and legends? Were expressions of safety concern punished?).

another one, probably one with upgraded features. Whether he might kill a neighbor or a child on the playground is remote from his contemplation, and exceedingly unlikely as an objective matter.

Clarity of rules. Before the NPRM becomes final, the substantive rules governing microdrones are confusing and murky. Where in the FARs is commercial drone flight prohibited? Nowhere, explicitly; one must infer the prohibition from various airworthiness, pilot certification, and operating rules that by their content seem applicable only to airplanes and helicopters. There is no explicit rule that says, "No person may fly a microdrone without FAA approval." Instead one must work the logic: microdrones are aircraft. No one may fly an aircraft unless it holds a type certificate indicating that it has met airworthiness standards. No one may fly an aircraft unless one holds an appropriate pilot certificate. No one may fly an aircraft except in compliance with the operating rules. Therefore I cannot fly my microdrone unless it holds a type certificate; I cannot fly it unless I have a pilot's certificate; and I must fly it only in conformity with the operating rules.

Self-esteem and reputation are not tied to a community. No microdrone "community" exists in anything like the same sense that the traditional aviation community exists.

Barriers to entry are *de minimis*. Anyone who really wants to can scrounge up a few hundred dollars to buy a Phantom on Amazon, and he can take it out of the box and begin flying it, however awkwardly, as soon as it arrives on his doorstep.[143] There is nothing special about being a member of a club that is so easy to get into.

No infrastructure exists for training or socialization. Most people who want to fly an airplane or helicopter think, "I need lessons." Most people who buy a Phantom Microdrone on Amazon believe they can fly it without any formal instruction.[144] Few already participate in model aircraft clubs, and they are unlikely to join. Model airplane operators traditionally fly their aircraft in conjunction with other members of clubs organized at the local level. Through the clubs, they exchange design ideas, compete to show

143. *See* NPRM, *supra* note 7, at 101 (noting that microdrones are easier to fly than airplanes or helicopters).

144. The co-authors have provided consulting and legal services to a number of individuals who bought microdrones intending to fly them for commercial purposes. All of them began flying the drones without any instructions—as indeed the co-authors did themselves. The only interest expressed in taking flying lessons was motivated by a concern that the FAA might require a pilot's license as a prerequisite for an exemption. Once they learned the cost of flying lessons, they lost interest in flight instruction but continued to fly their drones.

off their proficiency in flying, and generally help one another. Most DROPs are not active in such organizations, because their motivation is to take aerial photography, not to build vehicles and see how well they fly.[145] Moreover, the attractiveness of clubs and other casual, recreational social attachment appears to be diminishing. As Robert Putnam's popular book, *Bowling Alone,* explains, Americans are less and less likely to join organizations than they were half-century ago.[146]

It does not occur to a DROP that he is doing anything wrong when he flies his microdrone; the likelihood of a police officer reacting adversely to his activity is no more likely, he thinks, than that a police officer would object to his playing football with a buddy. And, he certainly has no fear that an FAA inspector will drop by; he probably doesn't know what an FAA inspector is.

The following television interview with the head of a firm that uses drones to take video of homes for sale illustrates the attitude of many DROPs toward compliance:

> "Paul Meincke asks: "Anybody from the FAA called you?"
> "Dan Isaacson: "No."
> "Meincke: "Said you can't do this?"
> "Isaacson: "No."
> "Meincke: "You gonna keep doing it?"
> "Isaacson: "Absolutely."[147]

B. Regulatory alternatives

Aviation regulation traditionally has stood on three pillars: certification of aircraft,[148] certification of airmen,[149] and rules for flight operations.[150] The certification processes for aircraft and airmen are mechanisms for imposing detailed requirements on vehicle design and manufacture and for the skills of personnel who operate and maintain aircraft.

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145. Mark Caylor, *Spotlight: Autonomous Systems*, MASS. INST. TECH. AEROASTRO (Oct. 23, 2014), http://aeroastro.mit.edu/videos-photos/videos/spotlight-autonomous-systems (oral comment on model aircraft operator motivation, compared with drone photography motivation).

146. ROBERT D. PUTNAM, BOWLING ALONE (2000).

147. Interview with Dan Isaacson, *See* Paul Meincke, *Drone Technology Races Ahead of Rule-Makers*, ABC 7 CHICAGO (Sept. 4, 2014), http://abc7chicago.com/technology/drone-technology-races-ahead-of-rule-makers/295546/.

148. 14 C.F.R. Subch. C (2015).

149. 14 C.F.R. Pt. 61 (2015).

150. 14 C.F.R. §§ 91, 119, 121, 135 (2015).

Requirements in the three areas are interrelated. For example, more demanding airmen requirements can compensate for more relaxed vehicle requirements, and more restrictive flight rules can compensate for simpler airmen or vehicle requirements. For example, section 61.101 of the FARs prohibits recreational pilots from carrying more than one passenger and from flying more than fifty miles from the airport of origin, unless the pilot has received additional instruction. [151] FAR section 91.319 imposes flight restrictions such as VFR-day only on experimental aircraft unless they meet additional certification requirements.[152]

Broad agreement exists that microdrone flight should be subject to some kind of limitations, whether to protect personal privacy, to protect aviation safety for manned aircraft, to protect persons and property on the ground, or some combination. How these limitations should be expressed, and how they should be enforced, however, presents a conundrum: microdrone technology is widely available, within the reach of virtually the entire population in a prosperous country; yet the traditional hallmarks of compliance with safety rules are altogether missing.

Recognizing that its ban on commercial microdrone flight was unenforceable and also inhibiting aviation progress, the FAA also recognized that merely trying to tweak its existing rules to accommodate drones would not match regulation to risk. It could have taken either one of two basic approaches: focusing, as the NPRM does, on the operator, or setting standards for the microdrones themselves. The latter approach would mimic airworthiness type certification for manned aircraft. It wisely elected to focus on the operator, with an affordable knowledge testing requirement. That approach mitigates the risks accurately identified in the preamble to the NPRM.

The agency recognized that focusing on the vehicle was an approach fraught with difficulty. [153] Airworthiness certification requirements[154] span hundreds of pages in the Code of Federal Regulations and address such things as removable ballast, length of takeoff roll, and stall speeds, among thousands of other details.[155]

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151. 14 C.F.R. § 61.101 (2015).

152. 14 C.F.R. § 91.139 (2015).

153. This conclusion is not only obvious from the content of the NPRM; it is reinforced by informal conversations co-author Perritt has had with senior FAA personnel, who emphasized that the agency was trying to stay away from airworthiness certification of drones.

154. 14 C.F.R. §§ 21-39 (2015).

155. *See, e.g.,* 14 C.F.R. § 23.31 (removable ballast); § 23.33 (propeller speed and pitch limits); § 23.49 (stalling speed); § 23.51 (takeoff speeds); § 23.53 (takeoff

Getting into the details of vehicle systems, components, and performance characteristics as in traditional airworthiness certification of manned aircraft could easily become hugely expensive. Requiring any kind of advance engineering certification of vehicles would delay innovation. Such a vehicle-centric approach is inconsistent with the consumer oriented microdrone market, where consumer preferences, product characteristics, and new uses change rapidly. The market needs to be nimble, and requiring advance approval of each new model of microdrone would make it sluggish.

The NPRM aligns drone regulation with the factors that encourage compliance.[156] Its content invites a perception of legitimacy, by sparing DROPs from onerous and largely irrelevant pilot-license requirements, and protracted and burdensome vehicle airworthiness certification. At the same time, it recognizes that a modest amount of microdrone-oriented training is appropriate. The testing procedure is straightforward, and not particularly burdensome, and how a DROP candidate learns the material is flexible, leaving room for self-study and flight-school programs—just as the current pilots' licensing regimes do. It looks remarkably like automobile regulation. Vehicles must be registered, operators must have operator licenses, and adherence to the microdrone equivalent of speed limits, one-way signs, and traffic lights is required.

The same characteristics result in a high score on the relative cost factor. It makes the cost of regulatory compliance commensurate with the cost of microdrones. The requirements are simple and clear, thus satisfying the clarity factor.

Implementation of the proposed rules will not, in and of itself, give rise to a DROP culture resembling the traditional aviation culture; nor will it produce reciprocal interaction among DROPs. Its testing requirement, however, may spawn the kind of training infrastructure that opens up the possibilities for a greater sense of community and reciprocity among DROPs.

Ithiel de Sola Pool, writing in 1990 about the interaction between law and new communications technologies,[157] observed that, historically, the most successful regulatory efforts have targeted what he called "chokepoints" in the market. When print on paper technologies dominated mass communications, the obvious chokepoint was the publisher's printing press. Now, frustrated with

performance); § 23.55 (accelerate-stop distance); § 23.155 (elevator control force in maneuvers); § 23.157 (rate of roll) (2015).

156. NPRM, *supra* note 19.

157. ITHIEL DE SOLA POOL, TECHNOLOGIES OF FREEDOM (1984).

a couple of decades of inability to enforce copyright law against end users of the Internet, copyright owners focus their enforcement efforts on choke points like content service providers such as YouTube and Internet service providers such as Comcast.[158] The only obvious chokepoint for microdrones is the point of sale.

C. Microdrones can automatically be law abiding

As Part B explains, the FAA wisely avoided a regulatory approach that prescribes the detailed design of microdrone vehicles.[159] Nevertheless, vehicle characteristics are important in any analysis of risk and regulatory alternatives. The NPRM regularly refers to the stark differences between and manned aircraft in explaining the choices it made in the NPRM.[160] Much of the discussion focuses on weight, the subject of § C.a, but an equally important difference is the high level of automation that microdrones already have; the prevailing multi-copter configuration is unflyable without significant onboard computing power acquiring information about position and direction of flight from on-board sensors and GPS. Evaluation of the NPRM and possibilities for modifying it,[161] therefore must proceed from an appreciation of the power of flight control automation built in to all of these aircraft. Regardless of what level of autonomy is offered by any particular model of microdrone, multicopters cannot fly at all unless their control systems are highly intelligent. Once the necessary degree of robotic intelligence is built-in, it is relatively trivial from an engineering standpoint and to add autonomy that enhances safety.

Moreover, rational training and skills requirements for DROPs must be based on an understanding of what DROPs actually do, considering the functions and maneuvers built into the vehicles they fly. Much primary training for helicopter pilots involves acquiring the fine motor skills necessary to hover a helicopter. When

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158. *See* Viacom Intern., Inc. v. YouTube, Inc., 676 F.3d 19 (2d Cir. 2012) (remanding for factual findings of whether YouTube met obligations to identify material infringing copyright).

159. The NPRM does not require any particular law-abiding technology, but such a requirement is possible in the final rule. "[T]he FAA invites comments on whether a flight termination system or other technological equipage should be required and how it would be integrated into the aircraft for small UAS that would be subject to this proposed rule. The FAA also invites comments, with supporting documentation, as to the costs and benefits of requiring a flight termination system or other technological equipage." NPRM, *supra* note 19, at 75.

160. *See generally* NPRM.

161. *See* NPRM, *supra* note 7, at 128 (inviting comment on segmented approach with simpler requirements for smaller microdrones).

autonomous hover is built into a microdrone, the DROP needs only a much lower level of skill.

The assessment of microdrone automation and autonomy in the following sections links particular capabilities to specific requirements in the NPRM. Multirotor aircraft are able to fly because their rotors generate thrust. When the thrust (the "lift vector") is directed upward, it results in lift. When it is directed forward, it pulls the vehicle forward. When it is directed left or right, it causes the vehicle to go sideways. The lift vector can be tilted by causing the different rotors to generate different amounts of lift. Pitching the nose down, directing the lift vector forward, for example, results when the rotors on the back generate more thrust than the rotors on the front. It would be extremely difficult for even the quickest, most agile, DROP to make the necessary adjustments in rotor RPM[162] manually.[163]

Instead, of requiring a DROP to make these adjustments directly, microdrone control systems call upon the DROP simply to issue commands by moving his control sticks to indicate what result he wants: climb, descend, go forward, go sideways, and at what speeds. The control-system computers aboard the microdrone translate these commands into the necessary currents to the motors.

When this level of control system automation exists, it is relatively easy to program the necessary computers to adhere to certain limits.

Most microdrones already on the market have some capability to hover autonomously.[164] Many also can take off, land, orbit a GPS waypoint, and return home autonomously. Many, like the Inspire, can be programmed not to fly outside of an envelope defined by maximum height, maximum radius, and maximum speed.[165]

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162. Multicopters, unlike helicopters, vary rotor thrust by varying rotor RPM, not by changing pitch of the blades. Rotor RPM is varied by changing the current delivered to the motor driving that rotor.

163. Indeed it would make hovering a helicopter, with only one rotor, seem easy by comparison.

164. PHANTOM 2 HIGHLIGHTS, http://www.dji.com/product/phantom-2/feature (last visited Mar. 11, 2015) (explaining precision flight and stable hovering).

165. PHANTOM 2 HIGHLIGHTS, http://www.dji.com/product/phantom-2/feature (last visited Mar. 11, 2015) (explaining position holding and altitude lock; no-fly zones); Inspire 1-Flight Limits and Flight Restriction Area, DJI WIKI, http://wiki.dji.com/en/index.php/Inspire_1-Flight_Limits_and_Flight_Restriction_Area (last visited Mar. 11, 2015) (maximum height and radius; no-fly zones); Iris+, 3D ROBOTICS, INC., https://store.3drobotics.com/products/iris (last visited Mar. 11, 2015) (automatic mission planning by drawing on moving map).

Specific airspace exclusions can be enforced directly by the microdrone software.[166] Relatively inexpensive moving map systems for manned aircraft automatically alert pilots that they are about to enter controlled airspace. The same geospatial referencing is used to prevent microdrones from flying into Class B, C or D airspace or into restricted or prohibited areas.[167]

When microdrone safety features like this strike a reasonable balance between utility and legitimate safety concerns, purchasers have little incentive to corrupt their vehicles so they would become outlaws.

Furthermore, the vehicles themselves can be made extremely difficult to corrupt. If a smartphone is designed to resist user modifications, only those with significant technical knowledge and a gentle touch can override design features. The same thing is true of consumer-oriented wireless networking devices. Causing an off-the-shelf wireless modem to transmit on the ILS frequency of a nearby airport is not easy and, furthermore, why would anyone want to? The difficulty of corrupting microdrone autonomy is similar.

The result is similar to encoding the law into computer software, an approach Lawrence Lessig evaluated and critiqued in his *Code and Other Laws of Cyberspace*.[168]

1. What does "law abiding" mean?

Built-in features make microdrones law-abiding by nature. They need not be required by regulation;[169] they result from the commands of the market. The law-abiding features already exist in

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166. Brian Fung, *You won't be able to fly this hugely popular drone in D.C. much longer, thanks to that White House crash*, WALL ST. J. (Jan. 28, 2015), http://www.washingtonpost.com/blogs/the-switch/wp/2015/01/28/a-simple-software-update-could-have-prevented-a-drone-from-buzzing-the-white-house/ (describing Washington no-fly zone feature added to DJI Phantom software).

167. *Compare* Phantom 2 Vision+ Flight Limits, DJI WIKI, http://wiki.dji.com/en/index.php/Phantom_2_Vision%2B_Flight_Limits (describing exclusion from Classes B, C, and D airspace) (last visited Mar. 11, 2015) *with* NPRM, *supra* note 9, at 14 (excluding microdrones from Class B, C, and D airspace).

168. LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE: VERSION 2.0 (2006) (arguing that restrictions embedded in code may restrict freedom more than conventional law does).

169. Modovolate Aviation, LLC, a firm that the co-authors established and control petitioned for a microdrone rule that would require microdrones to be law abiding, in this sense. Modovolate Aviation LLC, *Memorandum in Support of Petition for Rulemaking Seeking the Regulation of Small Unmanned Aircraft Systems*, FAA-2014-0473-0001 (proposed Jul. 10, 2014), http://www.regulations.gov/#!documentDetail;D=FAA-2014-0473-0001.

the most popular models of microdrone without a threat of regulatory requirement. Now, demand for these features will be even stronger because they make it easier for a DROP to comply with the regulatory limitations. They also make it easier for him to prove that he did not exceed the limitations if the FAA accuses him of doing so. If his vehicle cannot exceed the limitations, then he did not exceed them on any particular flight.[170]

Microdrones with these features obey the law automatically, without regard to what their operators may want them to do.[171] The following sections explain the relationship between particular types of autonomy and the NPRM requirements.

a. Weight and other restrictions on kinetic energy

The most basic law-abiding feature is weight. Limiting the weight of microdrones limits the amount of damage they can do if they crash or collide with other aircraft.[172] When one object hits another, the amount of physical damage depends on the kinetic energies of the two objects. All of the kinetic energy must be absorbed by bending, shattering, crushing, shearing, or penetration of the colliding objects.[173] This is so whether the objects are inanimate or animate. The bending, shattering, crushing, shearing, and penetration of an inanimate object is called "damage." When the colliding objects are two NFL football players, the bending, shattering, shearing, and crushing is called "injury."

Kinetic energy and thus the damage or injury depends on the mass of the colliding objects and the square of the speed with which they collide.[174]

If a small drone weighing less than, say, ten pounds were to collide with an aircraft, survivability would be much greater than if the aircraft collides with something larger. The alarmist argument

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170. One can imagine a factual adjudication in which the DROP responds to an alleged violation by offering demonstrative evidence that his drone will not flying higher than 500 feet AGL no matter what commands he gives it.

171. *But see* Kevin Poulsen, *Why the US Government Is Terrified of Hobbyist Drones*, WIRED (Feb. 5, 2015, 5:15 AM), http://www.wired.com/2015/02/white-house-drone/ (criticizing georeferencing that limits microdrone flights).

172. *See* NPRM, *supra* note 7, at 50-51 (noting that heavier aircraft can do more damage to people and property on the ground).

173. *See generally* Jerry Ogden, *Forensic Engineering Principles of Motorcycle Analysis*, ACADEMIA.EDU (June 5, 2014), http://www.academia.edu/9429958/Forensic_Engineering/Principles_of_Motorcycle_Analysis (explaining energy and momentum analysis in accident reconstruction).

174. $KE = 1/2\ m \times v^2$, where m is mass and v is velocity.

that a microdrone strike could bring down a 747 is nonsense. In order to be certified by the FAA, turbine engines for air transport aircraft must satisfy bird-ingestion tests.[175] The engines for the 747 and 787 must withstand ingestion of an eight-pound bird.[176] A DJI Phantom weighs 2.6 pounds, and a DJI Inspire weighs 6.4 pounds. The Movonator[177] weighs 6.72 pounds.

Moreover, most bird strikes are not catastrophic to engine operation:

> By far, most bird encounters do not affect the safe outcome of a flight. In more than half of the bird ingestions into engines, the flight crew is not even aware that the ingestion took place.[178]

On the other hand, bird strikes are the number two accident cause for helicopters.[179] In one case, the pilot was incapacitated when a bird penetrated the bubble.[180] In another, a larger bird

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175. 14 C.F.R. § 33.76(b) (2015) (requiring test with "large single bird" aimed at the most critical exposed location on the first stage rotor blades at a bird speed of 200 knots; requiring bird weights of 4-8 pounds, depending on engine inlet throat area). *See also* FAA, *Advisory Circular: Bird Ingestion Certification Standards*, AC No. 33.76-1A (Aug. 7, 2009), http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC 33.76-1A.pdf.

176. The GEnx engine used for the Boeing 787 and the 747-8 has a fan diameter of 111 inches for the 787 and 105 inches for the 747-8. This produces an engine inlet throat area of 9676.88 square inches for the 787 and 8364.67 square inches for the 747-8. An eight-pound bird is required to certify these engines. 14 C.F.R. § 33.76 Tbl. 1 (2015) (requiring tests with bird weight 8.03 pounds for engine inlet throat area greater than 6,045 square inches).

177. The Movonator is a Cinestar 8HL, with a payload of up to twelve pounds, a max gross weight of eighteen pounds, and endurance of up to twenty minutes that Movo Aviation is building.

178. *Airplane Turbofan Engine Operation and Malfunctions Basic Familiarization for Flight Crews*, FED. AVIATION ADMIN. 23, https://www.faa.gov/aircraft/air_cert/design_approvals/engine_prop/media/engine_malf_famil.doc.

179. Gail Keirn, *Helicopters and Bird Strikes; Results from First Analysis Available Online*, U.S. DEP'T OF AGRIC., http://blogs.usda.gov/2013/06/06/helicopters-and-bird-strikes-results-from-first-analysis-available-online (June 6 2013, 3:11 PM). *See also* Brian Washburn, et al, *Bird Strike Hazards and Mitigation Strategies for Military Rotary-wing Aircraft*, DEPT. OF DEF. LEGACY RESOURCE MGMT. PROGRAM, Project No. 11-944, https://www.dodlegacy.org/Legacy/project/productdocs/FINAL%20OSD%20Legacy%20Report%20Joint%20RW%20Bird%20Strike%20Hazardswithcomments%20FINAL_ff16305b-b450-4d1c-9050-4404d614c07c.pdf (Dec. 31, 2012) [hereinafter "Bird Strike Study"]. Helicopters are much more likely to be damaged by bird strikes than fixed-wing aircraft. Bird Strike Study, at 2.

180. The "bubble" is the Plexiglas enlarged windshield of a helicopter.

impacted the main rotor, causing it to separate and killing the occupants of the helicopter.[181] Larger birds caused more damages and more severe injuries.[182] Bigger birds have a mass bigger than that of the most popular microdrones now on the market.

Moreover:

> The extreme rarity of any collisions between birds and aircraft away from airports and at low altitude, despite the population of 10 billion birds, suggests that unintentional impact between UAVs and manned aircraft away from airports and low altitude will always remain extremely unlikely.[183]

The risk depends, as the discussion indicates, on mass of the microdrone. A Phantom or Inspire poses little threat, but a bigger drone with a bigger battery might. This supports the possibility, identified in the NPRM,[184] of a regulatory approach segmented by weight. It also supports the idea of adding microdrone ingestion as part of the airworthiness certification testing of aircraft engines.

As mass increases, kinetic energy increases linearly. Given the stronger relationship to velocity, one might wonder if regulation should focus on speed in addition to or instead of weight. Kinetic energy of a microdrone can be limited by imposing limits not only on its weight, but also in its velocity. The NPRM limits microdrone speeds to 100 miles per hour.[185]

An additional possibility is to require that microdrones be made of frangible material, as the FAA is considering for its "micro UAS" proposal.[186] Frangible material would break up into small pieces upon impact, requiring less energy to be absorbed by whatever object it hits. The NPRM notes that most microdrones currently on the market are already made of frangible material.[187]

A trade-off exists between weight and performance. A heavier microdrone can carry more mission equipment and a larger

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181. Bird Strike Study, *supra* note 181, at 2.

182. *Id.* at 17, 47. 200 bird strikes with U.S. civil helicopters were reported in 2011. *Id.* at 41.

183. Exponent, *UAS Safety Analysis*, UAS AMERICA FUND 7 (Dec. 16, 2014), http://www.uasamericafund.com/assets/micro-uav-safety-analysis.pdf [hereinafter "MIT Bird Study"].

184. NPRM, *supra* note 7, at 52.

185. NPRM, *supra* note 7, at 11 (summary of restrictions, referring to 100 mph limit).

186. NPRM, *supra* note 7, at 58.

187. NPRM, *supra* note 7, at 8.

battery, which means longer endurance. But perfectly adequate performance can be obtained at the ten to fifteen pound level, except possibly for microdrones intended to carry high-powered searchlights and more traditional Hollywood movie or ENG helicopter cameras. Otherwise, all the electronics and cameras capable of producing Hollywood quality HD video such as the Red camera[188] can be carried by microdrones such as the Movonator with a twelve-pound useful load and a gross weight of about twice that.

The FAA initially considered a more nuanced approach to microdrones, establishing multiple categories of A through E, based largely on weight. The preamble to the NPRM takes specific note of the UAS America Fund proposal, and describes in some detail a "micro UAS" regime for microdrones weighing less than 4.4 pounds. It invites comment on whether this should be part of the final rule.[189] The FAA concluded, preliminarily, that data are not available to support different types of restriction for different subclasses.[190] Ultimately, relaxing the requirements of the NPRM for the smallest microdrones, as the UAS America Fund proposed, may be desirable.

Speed restrictions should not produce much controversy, because microdrone missions require lower, not higher speeds. Higher speeds are desirable for manned helicopters or airplanes in order to reduce transit time. Microdrones do not generally fly to their mission site– they don't have the range or endurance. They usually are already there or are brought there on a ground vehicle.

b. Height

The NPRM limits microdrones to 500 feet above the ground ("AGL").[191] Height restrictions mitigate three risks. First, they have

188. The RED epic camera body weighs five pounds. *Epic Dragon*, RED DIGITAL CINEMA (last visited Mar. 12, 2015) http://www.red.com/products/epic-dragon#tech-specs.

189. NPRM, *supra* note 7, at 54-59.

190. NPRM, *supra* note 7, at 52-53.

191. Aviation regulations regularly distinguish between heights AGL and altitudes. Altitudes typically are measured with respect to Mean Sea Level ("MSL"). Because the elevation of terrain varies considerably, 500 feet AGL means an altitude above MSL of 1,240 feet at the Kenosha regional Airport ("KENW") which has an elevation of 740 feet. Altitude affects aircraft performance, which varies with air density, which in turn, varies with altitude. It also is relevant with respect to aircraft separation over larger geographic areas where the elevation of terrain varies. Heights AGL are more relevant with respect to operations in a limited geographic area, where the terrain elevation does not very much, and the height of a finite number of obstacles also is known.

the effect of separating microdrone traffic from most manned aircraft traffic. Second, they make it less likely that the DROP will lose sight of the drone. Third, they make it less likely that the control link will be lost.

FAR section 91.119[192] prohibits flying airplanes within 500 feet of any person or object on the ground. Section 91.119(d)(1) relaxes the floor for helicopters. Independent of this restriction, manned-aircraft pilots always fly at heights that assure a safe landing in the event of an engine failure. Apart from their own self-preservation instincts, the FARs require it.[193] For most helicopters, this is 500 feet or higher when airspeeds are less than about sixty knots.[194] Prudent airplane pilots fly significantly higher – 1,500-2,000 feet – because an airplane suffering an engine failure requires more space to land safely, diminishing the number of possible emergency landing points, and increasing the glide distance necessary to reach one.[195] If microdrones stay below 500 feet AGL, they will be out of the way of most airplanes and helicopters, most of the time.[196]

Of course, manned aircraft, like drones, have to take off and land. In order to do this, obviously they must be within 500 feet of the ground. So a 500 foot – or any other – height restriction for drone operations will not promote traffic separation in the vicinity of airports or other landing areas. Reducing collision risks in such areas requires excluding microdrones from controlled airspace around airports, as the NPRM does.[197]

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192. 14 C.F.R. § 91.119 (2015) (prohibiting flight, except for takeoff and landing, below 1,000 feet within 2,000 horizontal feet of any obstacle over congested areas and within 500 feet of any person, vessel, vehicle, or structure; exempting helicopters so long as they avoid hazards to persons or property on the surface).

193. 14 C.F.R. § 91.119(a) (2015) (prohibiting operation below "[a]n altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface").

194. Part of the airworthiness certification process for helicopters requires the generation of a "height-velocity diagram" that derives from test flights in which skilled test pilot must demonstrate successful autorotations to the ground from various height and velocity combinations. 14 C.F.R. § 27.87 (2015) (requiring generation of height-speed envelope).

195. A typical light or medium helicopter has a glide ratio of little more than four to one in a well-managed autorotation. That means that helicopter flying at 500 feet at sixty knots (a typical autorotation airspeed) can reach landing areas within 2,000 feet—or about half a mile–laterally, but not beyond. An airplane typically has a glide ratio of about ten to one. That means that an airplane flying at 2,000 feet at sixty knots (the typical power-off glide airspeed) can reach landing areas within 20,000 feet, or about four miles.

196. *See* NPRM, *supra* note 7, at 77-78 (discussing selection of 500-foot limit).

197. NPRM, *supra* note 7, at 183.

c. Line of sight

When the microdrone remains within line of sight of its DROP, two risks are reduced. First, the DROP can control it by looking at it; he just does not need more sophisticated FPV, graphical display, collision detection avoidance telemetry; nor does he need ATC communications that would be necessary to mitigate the same risks for a drone flown beyond the line of sight.[198]

Second, keeping the drone in sight is a rough proxy for keeping it within range of relatively low powered control links, usually implemented on currently available microdrones through Wi-Fi connectivity.[199]

Keeping a microdrone in sight involves limiting height and horizontal distance from the DROP. A microdrone at 500 feet directly over the DROP is easier to see in detail than one 1,000 feet away at twenty feet AGL; what matters is the actual range and not simply the height.

Moreover, seeing the microdrone in sufficient detail to determine its orientation, flight path, and distance from obstacles depends on visibility – the controllable range is much less on a foggy day than on a clear day. It also depends on the DROP's visual acuity and on the possibility that other objects might interpose themselves between the DROP and the microdrone.

Minimum visibility requirements are a mainstay of operating rules; the basic three-statute-mile minimum visibility for VFR operations at most altitudes[200] is a useful reference point for microdrone regulation. Visual acuity requirements are mainstay of airmen certification.[201]

And, as with the visual contact between DROP and drone, what matters is distance, not simply height. A microdrone directly over the DROP's head at 500 feet is likely to be well within control-link range; one at 500 feet AGL at a 1000-foot horizontal distance is likely to be out of range. This, as with maintaining visual contact, invites consideration of limits on operational radii as well as height.

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198. *See* NPRM, *supra* note 7 at 66-72 (discussing need for line-of-sight restriction as a substitute for traditional see-and-avoid requirement).

199. Use of Wi-Fi for control links has significant advantages. It uses unlicensed spectrum and spread spectrum technologies, which greatly reduce radio interference problems.

200. *See* 14 C.F.R. § 91.155 (2015) (imposing minimum visibility requirements at different altitudes in different kinds of airspace).

201. *See* 14 C.F.R. §§ 67.103; 67.203; 67.303 (2015) (prescribing vision requirements for first-, second-, and third-class medical certificates).

Line-of-sight restrictions can be problematic, however, if they are literally interpreted. It is hard to fly a microdrone in any realistic mission environment without occasionally flying behind a tree or a building. Indeed, some missions require that it be flown behind an obstacle, such as searching a backyard or an alley in a law-enforcement operation. The NPRM acknowledges that momentary loss of line of sight is not a violation.[202]

d. Autonomous functions

Control links can be lost, for microdrones as well as machodrones. What happens then? One way to mitigate risks is for microdrones behave in a certain way when they detect the loss of their control links. They can cut their engines and simply fall to the ground. They can reduce power and enter a controlled descent to the ground, wherever they are. Or, they can return to their launching point. None of these is foolproof. Cutting the engines simply results in a crash with whatever consequences result from weight and terminal velocity. A controlled descent to the ground reduces impact speed, but the consequences depend on what is underneath when the controlled descent ends. If a tree or a building is immediately below the drone when its control link is lost, this mode of recovery is certain to result in some damage to the drone, if not injury or damage to persons or property on the ground.[203]

The best response is usually autonomous return to home.[204] Even this, however, is not risk-free. The altitude when the control link is lost may not allow it to clear obstacles on its return flight. The speed of its return may be insufficient to overcome wind velocities. And, unless its control logic keeps track of remaining battery life, it may not have sufficient electricity remaining to make it all the way back.

e. Regulatory language

This Article emphatically does *not* recommend that airworthiness certification should be required of microdrones. It may turn out, however, that certain performance standards should be

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202. NPRM, *supra* note 7, at 67-68 (acknowledging possibility of momentary loss of sight).

203. *See* NPRM, *supra* note 7, at 79 (identifying various safe reactions to loss of control link; justifying performance-based rule rather than one requiring specific action).

204. *See* NPRM, *supra* note 7, at 74 (inviting comment on whether a "flight termination" system should be required).

imposed, especially on the heavier weight classes if they are permitted to fly outside the limits expressed in the NPRM. Moreover, the problem of rogue operators will persist. It is not yet clear whether a DROP knowledge testing and certification requirement, as proposed in the NPRM will be more effective than the current ban. The law abiding features discussed in the preceding sections can be understood as performance criteria to be applied by DROPs when they select their vehicles. Or, as the NPRM evolves, the FAA may determine that it is necessary to impose performance requirements for vehicle safety-features. In either event the criteria could be expressed as follows:[205]

> § 107.15(c) A civil small unmanned aircraft system meets the performance standards only if it satisfies the following requirements:
>
> (1) Height limit. The vehicle must have a navigational mechanism, a barometric pressure sensor (altimeter), and GPS navigational systems that will not permit it to fly more than 400 feet above ground level.
> (2) Radius limit. The vehicle must have a GPS navigational capability that will not permit it to fly more than 1500 feet horizontally from its starting point.[206] The distance may be decreased by the operator, but not increased.
> (3) Return to home. The vehicle must have a return-to-home feature that can be triggered by the operator, would be automatically triggered by loss of signal, and might be triggered by an indication that the operator has become inattentive similar to a "dead man control" or "alerter" on railroad locomotive.[207]
> (4) The control subsystem aboard the vehicle must have the following capabilities:
>
> > a) Detection of lost control link for more than a predetermined number of seconds, or

205. The text in this section is entirely the work of the co-authors. While it is presented following typical usage in the FARs, and the numbering is such that would fit comfortably within the numbering scheme of the NPRM, the same language could comprise non-mandatory specifications adopted by manufacturers or purchasers.

206. *See* NPRM, *supra* note 7, at 76 (inviting comment on whether numerical limit on horizontal boundary should be part of the final rule). The agency did not make such a limit part of its proposal because data are lacking to set a rational limit.

207. 49 C.F.R. § 229.140 (2015) (requiring alerters on locomotives).

b) Availability of one or more of the following emergency responses, performed without any intervention by the DROP.

i) Controlled vertical descent to the ground; or

ii) Controlled flight back to the launching point at heights no greater than 400 feet and speed no greater than thirty knots.

c) Obstacle avoidance in the return-to-home mode is optional.

The rule would also deal with control link integrity and their loss.

The aircraft must have an emergency lost-link subsystem that is capable of:

(a) Detecting a lost communications link within one second

(b) Causing the aircraft to perform the following maneuvers if the link is not restored within three seconds:

(1) Entering a hover

(2) Descending at no more than 300 ft./min., and

(3) Entering a controlled flight back to the launching point and performing a controlled landing at that point.

(4) The vehicle must have a mechanism for detecting diminishing strength of the control-link signal. When the signal strength reaches a certain minimum level, the vehicle must terminate flight further away from the DROP, and enter a regime in which it flies only in directions that increase signal strength.

f. Bandwidth availability

As microdrones streaming video back to the ground proliferate, available bandwidth may be taxed. As long as Wi-Fi is used, this problem is inherently limited because it would only affect microdrones within Wi-Fi range of each other. Many people send full-motion video images over their Wi-Fi connections in home and office local area networks, and they do not interfere with each other because their Wi-Fi networks are not within range of each other.

This is a problem that does not exist yet. Regulatory response should await concrete problems. Only then can they be tailored to how the problem manifests itself.

2. DROP training

Because almost anyone has the resources to buy a microdrone[208] and can fly it about as quickly as he can open the box it is delivered in, developing and enforcing DROP requirements present a considerable challenge. Someone who sees a pop-up ad on the Internet for a Phantom 2, available for one-day delivery from Amazon or dozens of other vendors, is not going to defer his purchase for a year while he spends $10,000 to get a pilot's license.

It does not make sense to subject microdrone DROPS to existing pilot certification requirements. Microdrones will not be flown cross-country. They will be affected only by local weather, and not by the vicissitudes of weather over a large geographic region. When microdrones experience loss of power they behave differently from either airplanes or helicopters—they just fall out of the sky. Existing requirements pertaining to these areas of operation by helicopters and airplanes are irrelevant to microdrone operations. The NPRM recognizes this in explaining why a traditional pilot's license should not be required.[209]

The NPRM appropriately embraces a regulatory approach that requires DROPs to be certified under a greatly simplified set of requirements, which reflect the reality that safe operation of microdrones depends on a variety of systems not found in manned aircraft, notably wireless control links and autonomous flight regimes.[210] The NPRM's certification requirements appropriately assure DROP knowledge and proficiency with these unique features of microdrones.

The NPRM leaves open the question of who will conduct training to prepare a DROP candidate for success on the test that it proposes. An on-line program of 2-3 hours training could do a more than adequate job of acquainting potential DROPs with the elements of knowledge proposed in the NPRM.[211]

Simply knowing how something works and what it is supposed to do is not enough; a DROP must actually be able to do it. That invites consideration of training infrastructure. Although the NPRM does not require training, flight experience, or practical

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208. Anyone who can buy a $10,000 used automobile can find a way to buy a $1000 microdrone.

209. NPRM, *supra* note 7, at 96-97.

210. NPRM, *supra* note 7, at 99-100 (explaining DROP knowledge test and recurrent knowledge testing requirements).

211. *See* NPRM, *supra* note 9, at 190-191 (specifying elements of knowledge to be tested).

tests,[212] such requirements might be added to the final rule. In any event, many DROP candidates might choose to undertake training. A number of alternative training infrastructures exist.

First, microdrone manufacturers might provide it. For example, Quadrocopter, a vendor of larger microdrones intended for professionals, offers two days of training, a simulator program, and a small practice drone as part of its $8,000 package.[213] Second, existing flight schools could add microdrone training programs.[214] Third, a private association could conduct DROP training, testing, and certification, much as exists for SCUBA divers.[215]

Existing microdrone operators, could be "grandfathered" out of the training requirement, if they demonstrate six months of safe operation of a microdrone without incidents occasioning police or FAA intervention or public complaints. This would exempt, for example, model aircraft hobbyists who, for the most part, fly only out of established model aircraft landing strips.

IV. MODEL AIRCRAFT

Model aircraft flying enjoys a statutory exemption from regulation under the 2012 Act.[216] Nevertheless, hazards from recreational flight of microdrones or small fixed-wing model aircraft are as great when they are flown for recreational purposes as when they are flown for commercial purposes. YouTube videos featuring FPV flying[217] make it clear that many model aircraft operators regularly fly heavy aircraft far beyond the line of sight and into clouds, where they pose collision hazards.

Model aircraft meeting all the statutory definitional requirements are not covered by the NPRM, but the NPRM preamble notes the FAA's statutory authority to bring enforcement

212. NPRM, *supra* note 7, at 99-103 (explaining why NPRM does not include flight proficiency demonstration or aeronautical experience requirements, and inviting comment on whether requirements should be added).

213. *See Cinestar 8 MK Heavy Lift RTF*, QUADROCOPTER (last visited Mar. 12, 2015). http://www.quadrocopter.com/CineStar-8-MK-Heavy-Lift-RTF_p_1156.html.

214. The co-authors have discussed this possibility with several flight schools.

215. *See Become a PADI Diver*, PADI (last visited Mar. 12, 2015). http://www.padi.com/scuba-diving/padi-courses/become-a-diver/learn-to-scuba-dive. A subsequent article by the co-authors will explore this possibility.

216. NPRM, *supra* note 9, at 45 (discussing statutory exemption for model aircraft).

217. *See, e.g.*, David Windestal, *FPV FunJet – Beautiful flight over the clouds – RCExplorer.se*, YOUTUBE (Nov. 12, 2009), https://www.youtube.com/watch?v=iI_UKiFqRsA (showing model airplane flight into and above clouds).

actions against model aircraft operators who endanger safety within the NAS.[218]

V. REINVENTING THE NAS

The NPRM does not accommodate delivery of packages by drone as Amazon has proposed. It does, however, invite comment on how package delivery can be accommodated.[219] Although the 2012 Act instructs the FAA to "integrate" drones into the National Airspace System, in fact the statute itself sketches features of a segregated airspace system, one in which microdrones are relegated to low altitudes where manned aircraft rarely fly, while manned aircraft continue to enjoy exclusive occupancy of higher-level airspace. Package delivery requires a different kind of segregation than that proposed in the NPRM. Package delivery requires low-level flight into neighborhoods by multiple vehicles, presenting a different kind of risk from that mitigated by operations under the NPRM. Amazon, Google, Domino's, and other enterprises depending on physical delivery of products to consumers will realize their aspirations for package delivery by microdrones[220] only after an advanced navigation and traffic separation system is developed and deployed.

At the request of the FAA, NASA has embarked on a major study and concept development project for how microdrones might operate safely in low airspace, mainly by relying on automated route-selection, traffic-detection, and collision-avoidance systems.[221]

How such a system might work is entirely speculative – the NASA effort is intended to crystallize some basic alternatives. Nevertheless, one can imagine a system modeled on the current IFR route system in miniature, one in which available routes are defined by geospatial data for highways, roads, streets, and buildings,

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218. NPRM, *supra* note 7, at 47.

219. The NPRM specifically invites comment on whether microdrones should be able to transport property for hire under the restrictions proposed by the NPRM. NPRM, *supra* note 7, at 39.

220. *See Amazon Prime Air*, AMAZON, http://www.amazon.com/b?node=8037720011 (last visited Apr. 21, 2015) ("The goal of this new delivery system is to get packages into customers' hands in 30" minutes or less using unmanned aerial vehicles). The NPRM specifically invites comment on whether microdrones should be able to transport property for hire under the restrictions proposed by the NPRM. NPRM, *supra* note 9, at 39.

221. *Civil UAV*, NASA (Mar. 21, 2015), http://www.nasa.gov/centers/dryden/research/civuav/civ_uav_index.html.

available for almost every part of United States.[222] Certain rules of the road would determine how and when a particular vehicle is entitled to use a particular block of space. The traffic control philosophy would be a hybrid of that currently resulting from traffic spacing requirements for ATC control of manned aircraft on IFR flight plans and the track warrant system increasingly used by railroads to make expensive ground-based signaling systems unnecessary. For example, drone flight might be permitted over expressways, major surface streets, or utility line right-of-ways at a height of 100 feet above the ground for traffic on headings of 0° to 179°, while traffic on headings of 180° to 359° would be required to fly at heights of 200 feet AGL.

Then, when a drone needs to land, it would obtain exclusive rights to the necessary residential street or alleyway in a manner roughly analogous to the way that a computer connected to a local area network obtains exclusive access to the network long enough to send one or a few frames. Building on that analogy, a microdrone entering a block defined by a range of street addresses on a particular street between two intersections, would broadcast a standardized signal evidencing its occupancy. Each microdrone anticipating entry into such low-density airspace would listen on the frequency, much as a network interface card on a LAN-connected computer listens to the LAN to see if activity is present. If activity is present, the second or subsequent microdrone would not enter until there is no "occupied" signal from the target.

In a similar fashion, microdrones would stay out of blocks of airspace occupied by manned aircraft, defined as, say, one mile horizontally, and 500 feet vertically.

Some form of this bifurcated NAS is likely to develop as demand for local delivery by drone builds.

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222. *See also* GOOGLE MAPS, https://maps.google.com (last visited Mar. 21, 2015); Kristin Majcher, *How Will We Keep Drones from Running into Things?*, MASS. INST. TECH. TECH. REV. (Jan. 21, 2015), http://www.technologyreview.com/questionoftheweek/534111/how-will-we-keep-drones-from-running-into-things/ (describing NASA research effort); Tom Simonite, *Air Traffic Control for Drones*, MASS. INST. TECH. TECH. REV. (Oct. 17, 2014), http://www.technologyreview.com/news/531811/air-traffic-control-for-drones/. (describing Airware/NASA project that will develop prototypes involving drone flight plans, automatic approval based on system knowledge of other drone flights, weather, and physical obstacles, evolving into active management relying on drone-to-drone signals).

VI. STATE, LOCAL, AND PRIVATE REGULATION

The limitations contemplated by the NPRM are not the only assurances of safe operation. As in all areas of human activity, tort law and insurance requirements limit what operators do if they are at all concerned about their economic security. Microdrone operation will be regulated not just by FAA rules when they are eventually adopted, but also by states and municipalities, by informal norms enforced by various self-help measures, liability for damages under general principles of tort law, and by coverage limitations imposed by aviation insurance.

A. State and local law enforcement

The essentially local character of microdrone flights invites a greater role for state and local governments than is traditional in aviation regulation. While states cannot enforce FAA regulations directly, they can enforce their own laws that prohibit conduct that endangers the public.

It is unlikely that states have the power to enforce FARs directly. States have no inherent power to enforce federal law.[223] As a general matter, judicial enforcement of FARs is reserved to the Secretary of Transportation and the Attorney General.[224] Even when a state lacks standing to enforce federal law, however, state courts presumptively have concurrent jurisdiction to hear claims by persons that do have standing.[225]

B. Federal preemption

Aviation regulation since the Civil Aeronautics Act of 1928 has been largely reserved for the federal government. Federal

223. Margaret H. Lemos, *State Enforcement of Federal Law*, 86 N.Y. UNIV. L. REV. 698, 708 (2011) (asserting that states have no inherent power to enforce federal law); Hawaii v. Standard Oil Co., 405 U.S. 251, 263-64 (1972) (affirming dismissal of state *parens patriae* suit for damages under Clayton antitrust act); Connecticut v. Health Net, Inc., 383 F.3d 1258, 1262 (11th Cir. 2004) (affirming dismissal of action by state to enforce ERISA; no evidence of Congressional intent to give states enforcement standing).

224. *See* Bonano v. East Caribbean Airline Corp., 365 F.3d 81, 84-85 (1st Cir. 2004) (holding that Congress meant to reserve enforcement of aviation regulations to the FAA); Schmelling v. NORDAM, 97 F.3d 1336 (10th Cir. 1996) (interpreting 49 U.S.C. section 46108 and holding that Federal Aviation Act does not grant private right of action to enforce FAA rules; affirming dismissal of action by former maintenance employer challenging dismissal for failing drug test).

225. Tafflin v. Levitt, 493 U.S. 455, 458-60 (1990) (holding that state courts have concurrent jurisdiction to adjudicate private civil RICO claims).

regulation preempts states and municipalities from adopting operating rules, aircraft requirements, or pilot qualification requirements that conflict with those adopted by the FAA. Even when the FAA has determined that a specific rule is unnecessary, or has implied such a determination by inaction, federal preemption applies under the "occupation of the field" preemption doctrine.[226]

States and municipalities retain the power, however, to make their courts available and to provide remedies for conduct that violates the federal standards.

Drones present special challenges to simple extrapolation of traditional federal preemption doctrine in the aviation field. Microdrone operations do not affect interstate commerce nearly to the extent that manned aircraft operations do. Microdrones do not have the capability to fly more than a mile or two. The commercial operations that are attractive economically are local in character. The effect of their operations on interstate commerce is attenuated. The justification for federal regulation of microdrones under the Commerce Clause is thus attenuated.[227] Their sale and distribution in commerce surely crosses state lines but their flight operations mostly do not. If an operator flies a microdrone within a mile or less of the state line, it may cross the line. Otherwise, it is almost certain to remain within a single state.

A robust concurrent regulatory and enforcement strategy is more appropriate for microdrones than it is for manned aircraft. The FAA's authority over airspace above a certain floor, say 400 feet, would continue, unquestioned, while state or local regulation that intrudes into that space would continue to be preempted. States and municipalities would have the power to regulate operations below that level. For low-level microdrone operations, however, some degree of standardization of state and local regulation is desirable, if only to ease the burden on state and local legislators in understanding the problem and crystallizing sensible approaches. Standardization also would make it easier for the states and localities to align the content of their regulations with the law-abiding autonomy required by the FAA for sale and distribution.

Legal space for state and local regulation will change the political equation. At a recent meeting of the National Association of Attorneys General where co-author Perritt made a presentation

226. *See* Ventress v. Japan Airlines, 747 F.3d 716, 721 (9th Cir. 2014) (describing field preemption).

227. *See* US Airways, Inc. v. O'Donnell, 627 F.3d 1318 (10th Cir. 2010) (analyzing interplay of field preemption, Commerce Clause, and 21st Amendment in case involving state regulator of airline liquor service).

on microdrones, other presenters and attendees expressed a strong desire that the FAA's approach leave room for state and local regulation. They also suggested legislative definition of new offenses which local police could charge.

C. Private enforcement of limitations

Setting ground rules for civil litigation occupies a middle ground between centralized prescriptive regulation by the FAA and self-help enforcement of informal norms. A variety of legal theories are available both to members of the public whose interests are adversely affected by drone flight and to drone operators who experience interference with their legitimate operations, including:

- Trespass, nuisance, the intrusion upon seclusion variant of invasion of privacy, intentional infliction of emotional distress, and negligence for persons injured by drone operations, and
- Conversion, trespass to chattel, and intentional inference with contract, for drone operators.

If tangible injury to persons or property actually has occurred, the negligence comes to the fore. If no tangible injury occurs, but only injury to intangible interests, only the other theories are available.

1. Trespass

Trespass to land is an intentional tort, the elements of which are:

- intentional
- entry onto the land of another
- without permission[228]

Damages are not an element of the tort, and so a plaintiff is entitled to nominal damages, and perhaps punitive damages and injunctive relief if he can establish the three elements.[229] Establishing

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228. RESTATEMENT (SECOND) OF TORTS § 158 (1965) (stating elements of trespass to land).

229. College of Charleston Foundation v. Ham, 585 F. Supp. 2d 737, 751-752 (D. S.C. 2008) (holding that punitive damages and injunction are available even when no proof of actual damage); Donahue Schriber Realty Group, Inc. v. Nu Creation Outreach, 181 Cal. Rptr. 3d 577, 587 (Cal. Ct. App. 2014) (holding that injunction for trespass to land requires a showing of irreparable injury).

liability is not difficult if a drone lands or falls on land belonging[230] to another. The harder question is when overflight at low altitudes constitutes a trespass.

As aviation matured through the twentieth century, landowners periodically sued aircraft operators for trespass and nuisance.[231] Most of the trespass cases confronted questions about how high above the ground the property owner's rights extend.[232] Above that height, trespass liability is preempted by FAA regulation. As for the manned aircraft, machodrone flight is unlikely to engender difficulty with height questions. This question of the vertical extent of property is less prominent for microdrone operations. A landowner's exclusive rights surely extend to 500 or 1,000 feet above the ground, as a handful of older aviation cases hold.

In the modern context, other questions of the spatial extent of property ownership present themselves. Issues will arise as to whether an individual condominium owner has standing to sue for trespass to his interest as a tenant-in-common for intrusions into the common areas of the condominium complex.[233] It is far more likely that a drone would fly over such common elements than into premises that are in the exclusive possession of a single occupant.

In less densely settled areas, drones flying over the property of another is far more likely to involve fight over undeveloped land such as forest or farmland.

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230. "Belonging" does not necessarily signify fee simple ownership; it includes any right to exclusive possession, such as under a lease or license as for a hotel room.

231. *See*, *e.g.*, Hinman v. Pac. Air Lines Transp. Corp., 94 F.2d 755 (9th Cir. 1936) (rejecting trespass liability for aircraft overflying private property).

232. *Compare* United States v. Causby, 328 U.S. 256, 264 (1946) (holding that military flights at eighty-three feet over plaintiff's property constituted a compensable "taking" because it encroached on plaintiff's property rights), *with* Laird v. Nelms, 406 U.S. 797 (1972) (holding that high-altitude flight creating sonic booms did not constitute a trespass); *See also* Pueblo of Sandia ex rel. Chaves v. Smith, 497 F.2d 1043, 1045 (10th Cir. 1974) (rejecting trespass action against aircraft operator because no proof of actual injury to concrete uses of land). "The landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land." *Causby*, 328 U.S. at 264.

233. Standing should exist, premised on the idea that a tenant in common has standing to sue for injury to the common property.

2. Nuisance

Nuisance allows the owner of an interest in land[234] to recover damages and obtain injunctive relief for and against unreasonable conduct on other land that injures the plaintiff's use of his land. Traditionally, this did not involve a balancing of interests; once the injury crossed an "unreasonableness" line, liability was established, and the plaintiff was entitled to at least injunctive relief. Now, the law for nuisance defines unreasonableness through a balancing of interests.[235] The Restatement of Torts identifies specific considerations on both the plaintiff's and defendant's sides, such as the suitability of the area for the activity stated in the complaint, and the relative cost to plaintiff and defendant of abating or avoiding the effects of the disputed activity.

Nuisance traditionally involved two pieces of land. Much drone operation will not be anchored to any particular piece of land owned or controlled by the operator. There is no suggestion in the Restatement's general rule for private nuisance that liability depends on the defendant's conduct arising out of the defendant's use of her own land.[236]

3. Invasion of privacy

The tort of invasion of privacy comprises four variants:

- intrusion upon seclusion
- giving publicity to private facts
- placing the plaintiff in a false light, and
- misappropriation of name or likeness.[237]

The most likely of these to be asserted in the microdrone context is intrusion upon seclusion. The others theories might arise, but they involve post-drone flight conduct not directly associated with drone operation itself, although they might involve imagery captured by a drone.

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234. *See* RESTATEMENT (SECOND) OF TORTS: WHO CAN RECOVER FOR PRIVATE NUISANCE § 821E (1979).

235. *See* RESTATEMENT (SECOND) OF TORTS: UNREASONABLENESS OF INTENTIONAL INVASION § 826 (1979) (embracing balancing of interests); *id.* at §§ 829-31 (balancing of gravity of harm against utility of conduct).

236. See RESTATEMENT (SECOND) OF TORTS § 822 (1979).

237. RESTATEMENT (SECOND) OF TORTS § 652A (1977) (identifying four variants).

Liability for intrusion upon seclusion depends upon establishing the following elements:

- intentionally
- intruding into areas
- where the plaintiff has a reasonable expectation of privacy,
- resulting in injury to the plaintiff.[238]

If a newsgathering drone is covering an apartment fire, and, while it does so, the operator pans the camera lens or yaws the drone so as to capture a momentary image through a bedroom window, the intentionality element is not met. On the other hand, if someone launches a microdrone for the specific purpose of peering in a bedroom window in the hope of obtaining imagery of intimate activity by the occupants, intentionality and expectation of privacy are satisfied, and the lack of legitimacy for the peeping activity also tilts analysis in favor of the plaintiff. If, instead, a drone captures imagery of people at a swimming pool in an apartment complex, liability is unlikely because it is hard to say that the swimmers and sun-bathers have a reasonable expectation of privacy there.

Invasion of privacy does not require proof that the plaintiff own or control property over which the drone flies. As the introduction noted, privacy is beyond the scope of this Article, just as privacy is beyond the scope of the NPRM. As the FAA notes in the NPRM, however, the torts discussed in this section provide some measure of background protection of privacy rights.

4. Negligence

Ordinary principles of negligence law provide a background of deterrence against risky conduct and a means for compensating people injured by it. There is no possibility that microdrone operations will enjoy any kind of immunity from these basic principles.

Under doctrines familiar to everyone who has passed the bar exam, the law imposes a duty on everyone to act so as to avoid foreseeable risks of harm. If someone breaches this duty, he is liable to compensate anyone injured as a proximate cause of the actor's conduct. So, if a DROP launches a microdrone with a damaged rotor and, as a result, the microdrone crashes on top of someone's

238. RESTATEMENT (SECOND) OF TORTS § 652B (1977).

luxury automobile and damages it, the DROP will be liable in negligence.

And, of course, the same principles backstop regulatory authority over microdrone vendors. If a microdrone designer fails to exercise prudent judgment in its design choices or manufacturing techniques, it may be liable in a products liability action – a species of negligence law.

But realizing the promises of negligence law's promise faces a number of obstacles. Many of the most careless and reckless people in society have few assets and thus a judgment against them for negligence liability is meaningless economically.[239] Furthermore, litigation is expensive. Investigations to prove what happened are time consuming and often require expensive, specialized private investigators and expert witnesses. Costs for litigating even a commonplace microdrone accident easily could cost $50,000 to $100,000. Plaintiffs' lawyers in negligence cases often work for contingent fees, but their business models prevent them from undertaking representation except in cases where liability appears relatively easy to establish and the potential damages are great. The result is that microdrone accidents involving a few hundred or a few thousand dollars almost certainly will be priced out of the litigation marketplace, leaving their victims uncompensated and letting the responsible parties off scot-free.

5. Barriers to civil litigation

Civil litigation presents transaction costs and barriers for lawsuits involving any of the theories developed in the preceding subsections. For it to be a significant part of the regulatory matrix, certain preconditions must be satisfied. There must be a viable defendant who can be served with process, and there must be one or more plaintiffs with standing to bring suit.

Suing a drone operator requires not only that he be seen by the potential plaintiffs, but also that he be identified. It is one thing to approach a DROP and say, "don't do that here;" it's quite another to get him to give his real name and address.

In this regard, involvement by the police might be helpful. Even if the police do not cite the operator for a crime or an offense, they are almost certain to require the DROP to produce identification, and should be willing to provide that information to the complaining party.

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239. Being able to afford a $1,000 drone does not suggest assets to cover a much larger damages judgment.

That leaves qualification of appropriate plaintiffs. Standing to litigate, a constitutional prerequisite for jurisdiction in federal and many state courts, and a common-law and prudential requirement in other state courts, allows only persons alleging injury to legally recognized interests to maintain civil actions. This will not be a difficult requirement to satisfy in the trespass context. It may be more difficult in the nuisance context; a plaintiff in a nuisance action lacks standing unless she can prove interference with her use of her own property.[240]

The most difficult party qualification problem will occur over microdrone flight in a public place – a playground or park. In those circumstances, the individual claiming harm will not be on his own property. The law permits individuals to maintain actions for public nuisance only when they can show some kind of special injury to their own property interests.[241]

Invasion of privacy claims also are problematic in this setting, because the public nature of the place makes it difficult to establish a reasonable expectation of privacy.

Even if a defendant can be identified and served, and a plaintiff with standing identified, the cost of litigation is a barrier. Even the simplest tort action is likely to cost several thousand dollars, and the cost can zoom upwards as soon as expert testimony is required. An individual is going to have to be very annoyed at a drone operator to be willing to finance a lawsuit. Costs for participants can be reduced by filing a class-action, but class-action is not maintainable unless a pattern of conduct exists that has nearly identical effects on every member of the point of class.[242] For the most part, each drone flight will be different from others, even when conducted by the same DROP. They will occur in different places, and involve different impact on different individuals.

Meeting the requirements for class-action litigation will be difficult, unless a property owners' association can establish injury to its members as a group.

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240. Brinston v. Koppers Indus. Inc., 538 F. Supp. 2d 969, 978-79 (W.D. Tex. 2008) ("The right to sue for a nuisance-based injury to property is a personal right that belongs to the person who owns the property at the time of the injury.").

241. RESTATEMENT (SECOND) OF TORTS § 821C(1).

242. Prerequisites for a class action, though they differ somewhat from state to state, are numerosity, typicality, commonality, and adequacy of representation. *See* Wal-Mart Stores, Inc. v. Dukes, 131 S. Ct. 2541 (2011).

6. Self-help enforcement

The absence of a tightly knit community with close ties to a regulator does not mean that norm-enforcement influences are absent. Individuals opposing a particular microdrone operation may engage in direct self-help, or they may encourage action by public authorities. Facebook and Twitter are alive with threats of use of force – typically shotgun blasts – against microdrones that fly on or near private property.[243] One can imagine other circumstances in which self-help will constrain microdrone flight. Imagine a widely publicized incident in which a microdrone is taking overhead video of volleyball games being played on the beach on the Chicago shore of Lake Michigan. One of them crashes, injuring a volleyball player.

It would not be unusual if the next time a volleyball player sees a drone nearby, that he might seek out the operator, approach him and say, "I'm going to beat the sh** out of you if you keep flying that thing around here." Or, a less belligerent player may simply say, "I'm going to call the police if you keep on doing that."

The law privileges certain types of self-help,[244] but the preceding—fanciful—examples likely go beyond the "reasonable force" limitation. Moreover, the privilege relates to defense against violation of legally recognized interests. There is no formal mechanism outside the regular political processes at the municipal, county, state, and federal level to translate community norms for microdrone operations into a legal rule, but articulable informal norms will develop, enforced by the general public, much as the "rules" for waiting in line are enforced.[245]

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243. A. J. McCarthy, *Meet Johnny Dronehunter, Shotgun-Toting Defender of American Privacy*, SLATE (July 30, 2014, 5:52 PM), http://www.slate.com/blogs/future_tense/2014/07/30/johnny_dronehunter_shotgun_toting_vigilante_shoots_down_drones_in_absurd.html; *12 Gauge – 3" Uranium Drone Load – Tacnition – 5 Rounds*, LUCKY GUNNER (last visited Mar. 21, 2015), http://www.luckygunner.com/12ga-3-uranium-drone-load-tacnition-5-rounds.

244. *See* RESTATEMENT (SECOND) OF TORTS § 63 (1965) (recognizing privilege to defend one's interest, but only with reasonable force).

245. *See* Frank Lovett, *A Positivist Account of the Rule of Law*, 27 LAW & SOC. INQUIRY 41, 51 (2002) (analyzing why people wait in line); Michael Reisman, *Lining Up: The Microlegal System of Queues*, 54 U. CIN. L. REV. 417 (1985). Standing in line is an example of:

> mundane microsituations—even with only two actors and of the shortest duration—[that] have the complex and significant normative components that are characteristic of law in its conventional usage. These components are essentially expectations, which are shared by the people in the situation. The expectations are first, the belief that there is a 'right' way of

These rules could be:

- do not fly at low levels near individuals or groups of people;
- do not fly so as to spy, or to appear to be spying, on residential dwellings; and/or
- do not fly at low levels over private property.

In addition to direct self-help, as in the examples cited, most ordinary citizens will simply call the local police if they are offended by drone activity. Local police have enormous discretion in deciding what incidents they respond to, the content of their intervention when they do respond, the laws they choose to enforce, and how they interpret them. Only a small fraction of police interventions turn into criminal prosecutions in court. Typically, an ordinary citizen approached by a police officer will cooperate with the officer. If he is flying a drone in, say, a public park, and a police officer asks him to fly it further away from a little league baseball game, he will probably comply.[246]

If the DROP is uncooperative, there are a variety of crimes and offenses with which he might be charged: disorderly conduct,[247] public endangerment,[248] refusal to obey the lawful command of a police officer,[249] or refusal to disperse.[250] The FAA has published guidance for local law enforcement personnel confronted with what they believe to be impermissible microdrone operations.[251]

This is the most likely scenario for "regulating" microdrone flight at low levels, regardless of the content of FAA drone

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> acting; second, the idea that defections from that 'right' way will lead to a shared subjectivity that the defection was 'wrong'; and third, the consensus that authorizes the injured party to respond in a way that ill hurt or sanction the offending actor and at the very least reaffirm the norm that has been violated.

Reisman, *Id.*, at 419.

246. Co-author Perritt's clients report exactly this kind of interaction with the police.

247. *See* 720 ILL. COMP STAT. 5/26-1 (2013) (disorderly conduct).

248. *See* MONT. CODE. ANN. § 45-5-207 (1987) (criminal endangerment).

249. *See* 720 ILL. COMP STAT. 5/31-1 (2014) (interference with public officers).

250. *See* City of Chicago v. Morales, 527 U.S. 41, 57-58 (1999) (affirming conclusion that gang-dispersal ordinance was unconstitutionally vague; explaining that laws criminalizing disobedience of police order are similarly questionable because of the possibility of arbitrary police orders); CAL. PENAL CODE §§ 409, 416 (refusal to disperse).

251. *See* FAA, *Law Enforcement Guidance for Suspected Unauthorized UAS Operations*, http://www.faa.gov/uas/regulations_policies/media/FAA_UAS-PO_LEA_Guidance.pdf.

regulations. FAA rules such as those proposed in the NPRM can be an influential back up for local law-enforcement intervention, regardless of whether local authorities characterize themselves as formally enforcing the FAA regulations.

In addition to direct self-help, individuals opposed to particular microdrone operations can provide information to public authorities thereby increasing the likelihood of detection of instances of rule noncompliance. Helicopter and airplane pilot reports of seeing drones at altitudes and places that create potential collisions are proliferating.[252] Pilots can take a variety of actions when they witness microdrone flight they consider hazardous.

The immediate reflex will be to call the FAA, but as § 1 explains, the FAA will never have enough resources to investigate every complaint about microdrone operation, let alone to enforce operating restrictions on its own. The pilot also might consider a report to local law-enforcement authorities, although that will require more effort to identify the appropriate authority; village, town, and county boundaries are not delineated on the ground with lines visible from the air and they are not marked on aeronautical charts.

A variety of actions are more reasonable. Conflict between drones and manned aircraft is more likely in areas with dense population. More low-level flight occurs in or near cities than in rural areas. Areas of dense population are where the density of law enforcement resources is greatest. A pilot or a group of pilots could collect data and evidence on hazardous drone operations, making FAA or local law enforcement intervention more effective. Most aircraft now have mechanisms for determining the latitude and longitude of aircraft position, whether through the avionics installed in the aircraft or through iPads or other personal devices carried by the aircrew. In many cases, the position of the DROP also would be visible to the aircrew, especially in a helicopter.

Local aviation groups could organize a data collection effort, and organize the results into a database, a "Drone Reporting Program" ("DRP") periodically making it available to the FAA and local law-enforcement. No one is likely to put forth the effort to track down the person responsible for every isolated errant drone flight, but individuals responsible for repeated incursions into congested airspace would be likely targets.

How the "DRP" could work:

A simple form would be distributed to pilots. The pilot would populate the form. Data from the forms would feed a DRP

252. *See* § 1 (offering examples of pilot reports).

database. The form itself would be kept on file to use in time of need or when it could benefit the FAA or NTSB with incident/accident investigation. This data could help aid policy makers make better decisions with new regulations regarding drone operations, as well as tracking known "hot spots" for drone activity for law enforcement if operations become an issue with manned aircraft.

Here's how such a private enforcement effort could work, once the DRP has data: Aviation groups, such as associations of pilots, maintaining the DRP, would report the more serious encounters and patterns to the local police, with whom they have developed an understanding. The police and the association would work out an arrangement for flying again in the area where the problem occurred, with police resources positioned on the ground to apprehend the offender.

The DRP database concept could easily be expanded to allow ordinary citizens to report, as well.[253]

There is occasional talk on the Internet about responding to unwelcome drone flight by jamming control frequencies.[254] This is not a good approach, and it is likely to increase the hazard. Most microdrone control links involve radio transmissions on the unlicensed 2.4 and 5.7 GHz bands – the same bands used for Wi-Fi and Bluetooth[255] Jamming these frequencies would create chaos for variety of spectrum users, including many aviation users. Moreover, the modulation technologies almost all are spread-spectrum, which means that the control signals and telemetry to and from drones do not take place on only one discrete frequency, but on one-hundred or more frequencies, each of which is occupied for only a millisecond or so.

253. Police tip lines, which exist in many jurisdictions, provide a precedent. *See*, *e.g.*, *Hotlines, Tip Lines and Important Numbers*, METRO. POLICE DEP'T, http://mpdc.dc.gov/service/hotlines-tip-lines-and-important-numbers (last visited Mar. 21, 2015); *How to Submit a Crime Tip*, L.A. POLICE DEP'T, http://www.lapdonline.org/contact_us/content_basic_view/23489 (Mar. 21, 2015); *Anonymous Tip Lines*, CITY & CNTY. OF SAN FRAN. POLICE DEP'T, http://www.sf-police.org/index.aspx?page=41 (Mar. 21, 2015); *Crime Prevention Tip Lines*, MICH. STATE POLICE, http://www.michigan.gov/msp/0,4643,7-123-1589_3492--,00.html (Mar. 21, 2015).

254. *See generally*, Survivalistdaily, *How To Build A Radio/Drone Jammer*, BEFORE IT'S NEWS (June 15, 2013, 9:08 PM), http://beforeitsnews.com/survival/2013/06/how-to-build-a-radiodrone-jammer-2477364.html.

255. Sue White, *Wi-Fi and Bluetooth Coexistence*, ECN (Mar. 2, 2012, 5:56 AM), http://www.ecnmag.com/articles/2012/03/wi-fi-and-bluetooth-coexistence (explaining frequencies used and potential for interference).

D. Insurance

Many rules that shape and contain the behavior of manned aircraft pilots, mechanics, and operators are adopted and enforced, not by the FAA, but by aviation insurance carriers. The rules are expressed in the form of limitations contained in the contract of insurance, and they are self-enforced by the insureds, who are not willing to take the risk that the insurance coverage they paid for will be denied if an insurable event happens.

It is, of course, possible to insure against almost any kind of risk. Hull insurance in the aviation industry can easily protect a drone owner and operator from damage to the drone. If the vehicle carrying the drone to a mission is involved in an accident, destroying the drone, the injured party files a claim and receives an insurance payout to the limits of the policy, less the deductible. Liability insurance protects the drone operator from negligence or other tort claims, covering the cost of litigation as well as any damages judgments up to the policy limits, less the deductible.

Insurance also is available to protect against a multitude of economic risks – inability to meet the requirements of a microdrone mission contract, for example.

Insurance policies contain rules. An insurer will not write coverage unless the insured obligated itself contractually to conduct its operations so as to reduce risk. And, when the policy is in force, violation of certain terms and conditions in the policy vitiate coverage. In others words, a claim arising out of conduct that violates the terms of the policy need not be paid, and an economically rational insurer will not pay it.

In most commercial and industrial enterprises, insurance restrictions have more influence on the organization and implementation of its activities than do the contents of statutes and governmental regulations. Few commercial aircraft operators will hire a pilot who does not satisfy the minimum requirements of the Named Pilot or the Other Pilot Waiver provisions of its insurance policy.

Many microdrone operators will not, in the near-term, bother with insurance, but as inevitable mishaps and lawsuits occur, they will begin to pay more attention to their possible liability when their vehicles injure someone or damage property. That will induce business entities first, and then many individual operators, to apply for insurance. In the meantime, as the world gains more experience with microdrones, as well as their advantages and risks, aviation insurance industry underwriters will be working through their risk

analyses so they can design products that are priced appropriately for the exposure of the insurer.

The result will be policy limitations that prescribe DROP qualifications and operational profiles. It is far too soon to predict the content of these limitations, but it is reasonable to assume that the underwriters will start with approaches already part of the dialogue, including the approach recommended by this Article.

The market for microdrone insurance is in its infancy, and it is hard to say exactly what conditions are likely to be typical for microdrone insurance. One can, however, assert four propositions with confidence. First, the initial policies will be relatively conservative, and are likely to require some degree of DROP training and certification before their activities are covered. Second, operations in violation of FAA rules almost certainly will not be covered, as they are not with conventional aircraft policies.

Third, law-abiding drones—those incapable of violation FAA rules—will be viewed favorably by insurers. Fourth, many of the highest risk operations will be conducted by individuals who have no training, no assets to satisfy negligence judgment, and no insurance. There is no reason to expect that the uninsured DROP problem will be smaller than the uninsured motorist problem.

In the short term, tort litigation and insurance limitations will do more to shape the behavior of microdrone operators than anything the FAA does.

VII. CONCLUSION

Microdrones represent a disruptive aviation technology that calls for new regulatory strategies. The FAA's NPRM is a thoughtful approach that strikes a good balance between allowing the benefits of the new technology to be realized while mitigating its risks. Alternatives imposing traditional aviation regulatory requirements are undesirable and likely to produce widespread noncompliance, thereby increasing risks rather than reducing them.

If more stringent regulation than the NPRM proposes is desirable, it could take the form of requiring built in, technology-based limitations on drone flight. Any such requirements should be performance-based rather than imposing detailed engineering requirements. Such expansion of regulation is unlikely to be necessary, however; the market already has encouraged microdrone suppliers to incorporate such features.

Any regulatory strategy must take into account the wide variety of private remedies for irresponsible microdrone operations,

including self-help, local enforcement, and economic incentives arising from potential tort liability and insurance limitations.