Hastings Science and Technology Law Journal

Volume 7
Number 2 *Summer 2015*

Article 2

Summer 2015

Developing DROP Discipline: Training and Testing Operators of Small Unmanned Aircraft Systems

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I. Introduction

Small drones—"microdrones"—are taking the United States by storm. Thousands, maybe tens of thousands, of people are buying them on ecommerce sites and trying them out. They are not hard to fly in benign environments. They can take off with the push of a button, hover automatically when the controls are released, and automatically return to the launching point when something goes wrong.

In many cases, the purchasers view them merely as high-tech toys. Many, however, discover that their onboard HD video cameras can be astonishingly useful in capturing overhead imagery to give real estate marketing packages new sparkle, to enable reporters and news photographers to jump cameras into the air over a fire, a hostage situation, or a vehicle crash, to allow construction contractors to program them to fly back and forth to monitor progress on a construction site, to permit public safety personnel to fly a grid to search for a fugitive or a missing person; to provide new tools to agricultural insurers to check crop damage.

The Federal Aviation Administration ("FAA") prefers to call them "small Unmanned Aircraft Systems"—"sUAS". Most everyone else calls them "drones." Whatever they are called, these new types of air vehicles portend a revolution in aviation, making available the fruits of fifty years in research and development in automatic control systems, semiconductor miniaturization, composite fiber materials, and battery development in packages that cost less than a high-end HD television.

A vexing problem that confronts adopters of any new technology is matching the technology with the people who use it. Although engineers can take the latest lab results in structures, miniaturized computing power, navigation algorithms, and sensors and turn them into products that have traction in the marketplace, they cannot engineer the people. Operators pretty much come as they are. They can be trained, tested, and granted governmental licenses or private certificates of competence, but the limits of their physical capacities and mental processing agility is ingrown. Any good engineer pays close attention to this and makes sure that her system design accommodates human limitations.

Managers know that they must embrace new technology at the right time, neither taking on too much risk as early adopters, nor waiting so long that the competition gains an advantage. They struggle to figure out whether their existing workforce can be retrained and redirected to use the new technologies, or whether they must recruit new and more flexible talent. They choose between recruiting the best raw talent and molding it or limiting their hiring to those that already have proven their capacity. Is a licensing system in place? If so, what level of licensing must the operator have? Is an undergraduate college or graduate degree necessary? Can additional training be arranged by contracting with specialized schools?

Sometimes—as is the case so far with microdrones—innovation struggles against governmental restrictions premised, not on the features of the new technology, but on risks presented by old technology. Now, the FAA has crossed a bridge by responding to a statutory mandate to integrate microdrones into the National Airspace System by 2014.[1] On February 15, 2015, it issued a notice of proposed rulemaking ("NPRM")[2] that wisely rejected the idea of subjecting microdrones to the burdens of traditional aircraft, pilot, and operational requirements designed around the risks posed by airplanes and helicopters. Instead it adopts performance standards for DRone OPerators ("DROPs"), reinforced by a knowledge test tailored to what they need to know, and a simple set of limitations that confine microdrone flight to the proximity of the DROP. The NPRM recognizes that the FAA was fighting a losing battle to prohibit commercial operation of microdrones, and that a mismatch between regulatory requirements and reality would produce a market in which the principal regulator of aviation safety is ignored.

The NPRM recognizes that microdrones do not fit the regulatory matrix developed over the last century for airplanes and helicopters with people on board. It has adopted an approach for matching the people with the technology. It concludes that, while microdrones are much simpler to fly than airplanes and helicopters because of their computerized controls systems, their DROPs nevertheless need to understand the national airspace system, and the ways in which manned aircraft maneuver through it. That leads to the knowledge test requirement.[3] The FAA wisely has molded the content of the DROP knowledge test to the things DROPs need to know, as opposed to the things airplane and helicopter pilots need to know to fly hundreds or thousands of miles in varying weather, and to deal with emergencies like engine failures leading to glides or autorotations.

While the knowledge test will be developed by the FAA itself and administered through the existing network of private testing centers accredited by the FAA, the NPRM leaves open the question of how DROP candidates will prepare for the knowledge test and acquire the skills necessary to fly their

1. FAA Modernization and Reform Act of 2012, 112 P.L. 95, 126 Stat. 11 §333 (2012).

2. FAA, OPERATION AND CERTIFICATION OF SMALL UNMANNED AIRCRAFT SYSTEMS; PROPOSED RULE, 80 Fed. Reg. 9544 (Feb. 23, 2015) (hereinafter "NPRM") (an NPRM is the first formal step in promulgating federal rules that have the force of law).

3. *See id.* at 103-07 (discussing need for a knowledge test).

microdrones safely. Implicitly, the NPRM recognizes that a rich array of private-sector training, testing, and certification regimes can meet the needs of the emerging microdrone community, while protecting the existing aviation community and the general public from unsafe operation. DROPs do not need traditional pilot's licenses to operate safely, but they do need training on the particular risks associated with microdrones, especially their automatic control systems and wireless control links. The best way to deliver the training, test training results, and certify competence is through a new infrastructure of private associations working in conjunction with the FAA, linked to its DROP knowledge test.

While this approach is tailored to new realities, it does not differ materially from the long-standing governmental-private partnership that trains, tests, and certifies airplane and helicopter pilots. It focuses the efforts on the problem to be solved instead of trying to shoe-horn microdrones into a traditional framework that does not fit.

This article begins, in section II, by describing the features of typical microdrones, highlighting the main requirements of the NPRM, and emphasizing the validity of the FAA's rejection of calls to impose a requirement that DROPs have a traditional pilot's license—a requirement the FAA itself had insisted upon in its grant of some 25 exemptions from its ban[4] and that the Air Line Pilots Association had urged be made even tougher.[5]

It probes the economic and political factors that will come to bear as the FAA and others defend its appropriateness in the NPRM, in section III.

0The articles then moves, in section IV, to explain that compliance with any regulatory regime depends on cultural factors that encourage compliance, and argues that FAA regulation of microdrones will be far more effective if a community of DROPs emerges resembling the long-standing community of aviators. More than a testing requirement is necessary for that to happen.

Section V explains why the Delegation doctrine does not prevent an administrative agency from giving a significant role to private sector actors in implementing a mandatory regulator regime.

Section VI moves to explain the content of desirable requirements for DROPs, beginning with the concept of validation—the need to relate selection and certification requirements to specific competencies necessary to reduce risk. It works through the major areas of knowledge identified in the NPRM and explains why they are necessary, while also justifying the exclusion of other skills and knowledge needed by airplane and helicopter pilots but not by DROPS.

4. Petition for Exemption No. 11138 at 13-16, *Douglas Trudeau, Realtor*, No. FAA-2014-0481 (discussing requirement for private pilot's license requirement and additional microdrone training and experience, in grant of section 333 petition).

5. *See id*. at 9 (describing ALPA's advocacy of a commercial pilot requirement, in grant of section 333 petition).

Finally, in section VII, it proposes one or more private associations that would develop and deliver DROP skills training programs and certification, prepare DROP candidates for the new knowledge test, and work with the FAA to refine knowledge testing and other requirements for DROPs.

To be sure, the growing debate over regulating microdrones—one certain to intensify during the comment period on the NPRM—is not limited to a debate over DROP training and licensing requirements alone. It also involves consideration of height, range, weight, and geographic limitations expressed in operating rules, debate over what features should be required of onboard control systems and their ability to operate autonomously to limit the risk of irresponsible DROP decisions, and identification and data transmission requirements to enhance collision avoidance and enforcement.[6] To require a $7,000 private pilot certificate,[7] or as Airline Pilot's Association ("ALPA") would prefer, a $40,000-$200,000 commercial certificate,[8] to operate a $900 microdrone over one's own farm or vacation home is a powerful impediment to further deployment of this technology. It is important that the FAA resist such proposals.

6. *See* NPRM, *supra* note 2, at 84 (discussing exclusion from Classes B, C, and D airspace); *id*. at 124-30 (discussing registration and marketing requirements).

7. *Pilot Certificate Options and Timeline*, AIRCRAFT OWNERS AND PILOTS ASSOCIATION, http://www.aopa.org/letsgoflying/ready/time/options.html (last visited on Mar. 20, 2015) (estimating total cost of obtaining private pilot's license as $5,000-$7,000; explaining requirements and timelines).

8. The cost of commercial pilot certification varies widely, depending on whether the candidate combines the requisite flight training with getting an undergraduate degree. It costs less, of course, to omit the degree. Then the cost is on the order of $36,000, representing the sum of the cost of a private license (say $7,000), the cost of further training for the commercial license (say another $8,000), and the cost of flight time to accumulate the required 250 hours (210 hours at $100 per hour, to be added to the 40 hours accumulated for the private license. *See, e.g. Commercial Pilot Training - Accelerated Commercial Pilot License - Flight Training Course (Single Engine, Initial)*, SUN STATE AVIATION, http://www.sunstateaviation.com/commercial.html (estimating cost of commercial license as $4443 for private pilot with at least 240 total time); *Commercial Pilot Pricing*, TOUCH-N-GOES AVIATION (last visited on Mar. 28, 2015) (estimating http://www.touch-n-goes.com/commercial/commercialpilotpricing.html cost of commercial license at $7,950 for holder of private license with 250 hours total time). Undergraduate programs combine the cost of flight training with tuition. *See, e.g. Tuition and Estimated Costs: Fall 2014 - Spring 2015*, EMBRY-RIDDLE AERONAUTICAL UNIVERSITY, http://daytonabeach.erau.edu/ admissions/ estimated-costs/ (last visited on Mar. 28, 2015) (estimating tuition for degree program as $43,198 per year and flight-student costs at an additional $81,000); *Tuition and Fees*, LEWIS UNIVERSITY, http://www.lewisu.edu/welcome/offices/business/bursar/tuitionrates.htm (last visited on Mar. 28, 2015) (estimating degree-program tuition as $13,915 per semester); *Aviation Flight Management, B.S.*, LEWIS UNIVERSITY, http://www.lewisu.edu/academics/aviation/flight-management/ (last visited on Mar. 28, 2015) (plus $7,000 to $8,000 per semester for flight training). So the cost of a bachelor's degree and multi-engine commercial rating from Lewis University would be about $176,000.

This is the third in a series of articles about drones by the co-authors. The first, *Drones*,[9] introduces the subject and explores the technologies that makes microdrones so useful and so inexpensive. It provides an overview of technological, economic, political, and regulatory issues that the second article and this one explore more deeply. The second article, *Law Abiding Drones*,[10] argues that the character of microdrones justifies simplified regulation as consumer products, with automated flight control and safety systems that make flying them easy, compared with airplanes and helicopters. This article focuses on the question of operator qualifications. It does not repeat the details of its overview of microdrone potential, the subject of the Vanderbilt article, or the analysis of microdrone control systems, the subject of the Columbia article. The three articles complement a number of magazine articles written by the co-authors.[11]

II. The Current Market and Regulatory Regime

A. Microdrone Vehicles

The DJI Phantom[12] and its more recently introduced, larger, sibling, the DJI Inspire[13] are archetypal microdrones. Both are quadcopters—vehicles that produce thrust with four motors at the end of booms that drive rotors. The thrust generated by each rotor is determined by varying the RPM of the motor. Unlike helicopter rotor blades, the blades of the microdrone rotors have fixed pitch.

9. 17 VANDERBILT J. SC. & TECH. L. 101 (2015).

10. To be published in the COLUMBIA SCI. TECH. L. REV.

11. Henry H. Perritt, Jr. & Eliot O. Sprague, *Drones*, 17 VANDERBILT J. SC. & TECH. L. 101) (hereinafter "Perritt & Sprague"). *See also* Henry H. Perritt, Jr. & Eliot O. Sprague, *Is there a drone in your future?,* HELIWEB 14 (May 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Drone Dread*, ROTOR & WING MAGAZINE 34 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *But Who's Going to Fly Them?* PROFESSIONAL PILOT 94 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Law and Order in the Skies*, THE TECH (MIT student newspaper) 13 (June 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Leashing Drones*, ROTORCRAFT PRO (July 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Law Abiding Drones*, ROTOR & WING MAGAZINE (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 (Oct., 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Ready for the Microdrone Races*?, NEWSLETTER OF THE RADIO TELEVISION DIGITAL NEWS ASSOCIATION (Oct. 29, 2014); Henry H. Perritt, Jr. & Eliot O. Sprague, *Reigning in the Renegades*, VERTICAL MAGAZINE (forthcoming Dec./Jan. 2014-2015); Henry H. Perritt, Jr. & Eliot O. Sprague, DOMESTICATING DRONES: THE TECHNOLOGY, LAW, AND ECONOMICS OF UNMANNED AIRCRAFT (Ashgate Publishing, under contract for delivery Oct. 2015).

12. *Phantom 2 Vision+*, DJI, http://www.dji.com/product/phantom-2-vision-plus (last visited Mar. 24, 2015) (summarizing design and performance of DJI Phantom 2+).

13. *Inspire 1*, DJI, http://www.dji.com/product/inspire-1 (last visited Mar. 24, 2015) (summarizing design and performance of DJI Inspire).

Onboard computers and electrical control circuits on a control board and power distribution board determine how much electrical current should be delivered to each motor to control its RPM—more current, more RPM. By delivering different levels of current to the different motors, the control system adjusts the attitude of the vehicle and permits it hover, climb, descend, fly forward, backwards, or sideways.

Electrical power is delivered to the motors through the power distribution board from an 11.1 V, 10,000 milliampere hour lithium polymer battery that has sufficient capacity to power flights of 20 minutes to 30 minutes. The battery also delivers electrical power to peripherals, such as a built-in two- or three-axis camera gimbal and a camera. Different models of the Phantom are configured to carry a GoPro camera or a built-in DJI camera with similar still photography and full-motion video capture capability.

The Inspire has bigger motors, larger rotors, and thus can carry a greater payload, up to and including the popular RED camera used for moviemaking. It also has a larger and more sophisticated gimbal. Basic microdrone configurations like these can carry other types of sensors more useful for surveying and also can carry small objects such as advertising banners.

The control board has GPS receiver and associated computer logic that permit these microdrones to determine their position in space and to maintain it or to fly a programmed pattern. The control board also has a magnetometer—an electronic compass—a barometric altimeter that measures altitude, and, in the case of the Inspire, a downward looking sonar sensor that provides more accurate indications of height above the surface. Finally, the control boards have an inertial measurement unit ("IMU") comprising three accelerometers that permit the drone to know its direction of movement and acceleration. The combination of the IMU, the altimeters, and the magnetometer allow the drone to know its position even when an adequate GPS signal is unavailable, although GPS navigation is more accurate.

The vehicles have transceivers tuned to the 2.4 and 5.8 GHz bands that receive control inputs from the DROP and send them to the control board and transmit telemetry data with position, speed, altitude, direction of flight, and battery power remaining, and stream the video captured by the camera.

The control board integrates DROP commands, data from its sensors, and a geographic database similar to Google Maps. The control board is also programmed to enable automatic hover when no control inputs are being received and to return home autonomously in the event of a malfunction, such a loss of control-link signal or impending battery exhaustion. The programs also prevent the DROP from flying into controlled airspace or near airports, above a certain height, and beyond a specified range. They also allow the DROP to specify a flight path to be flown over the ground by tapping waypoints on a map display.

The DROP controls the vehicle by moving two joysticks and adjusting switches on a small console ("DROPCON") that can be worn on the strap around his neck. A helicopter pilot flying the drone interprets the left joystick as the collective, controlling thrust by upward and downward movement and the right joystick as the cyclic, controlling pitch and roll and thereby direction of flight. Yaw is controlled by moving the left joystick left and right.

The Inspire can accommodate two DROPCONS, one used by the DROP, and the other used by a separate photographer who controls the camera and its gimbal. Serious photography missions benefit from having two persons, the DROP to fly the vehicle, and the photographer ("photog") to concentrate on the imagery being captured.

Each DROPCON has a transmitter to send the control signals to the vehicle, receivers to acquire the downlink telemetry and video signal, and an iPad-Mini-sized LED video display that allows the DROP (and a separate photog) to see the imagery captured by the onboard camera.

Prices for the Phantom range from $700-$1200, depending on whether the purchaser supplies her own camera.[14] The price for the Inspire is just under $3000.[15]

Many competitive alternatives exist, of course, comparable in price and performance to the Phantom and Inspire.[16] Larger hexacopters and octocopters are also available at prices ranging from under $10,000 to about $20,000.[17] These bigger vehicles can carry considerably more payload and, in some cases, have significantly greater endurance, up to an hour.[18]

B. The FAA Ban and the NPRM

Before the NPRM was released, the FAA took the position that commercial flight of drones is illegal unless one obtains an exemption from FAR compliance under section 333 of the 2012 Act, registers the drones, and also obtains a Civil Certificate of Authority ("COA") for specific flight programs.[19] Presumably the ban remains in effect—at least in principle—until

14. *Phantom 2 Vision+ V3.0*, DJI, https://store.dji.com/product/phantom-2-vision-plus?position=1 (last visited Mar. 24, 2015) (quoting prices for various models of Phantom).

15. *Inspire 1 & Accessories*, DJI, https://store.dji.com/inspire-1 (last visited Mar. 24, 2015) (quoting price for Inspire 1).

16. *IRIS+*, 3D ROBOTICS INC., http://3drobotics.com (last visited Mar. 24, 2015).

17. The CineStar H8L is an example. *See* CineStar 8, FREEFLY SYSTEMS, http://freeflysystems.com/products/cinestar/8 (last visited Mar. 24, 2015)

18. Walkera QR X800 Pro Film Quadcopter, EPFILMS, http://epfilms.tv/walkera-qr-x800-review-best-aerial-filming/ (last visited Mar. 24, 2015) (reviewing 8.6 pound multicopter claiming up to one hour of endurance).

19. *See, e.g.*, Section 333, FEDERAL AVIATION ADMINISTRATION, https://www.faa.gov/uas/legislative_programs/section_333/ (last visited Mar. 24, 2015) (FAA guidance on seeking Section 333 expemptions for microdrones); Documents relating to Docket CP-217: Huerta v. Pirker, NATIONAL TRANSPORTATION SAFETY BOARD, http://www.ntsb.gov/legal/alj/Pages/pirker.aspx (last visited Mar. 24, 2015) (reversing ALJ decision and reinstating FAA ban).

the NPRM completes the comment process and emerges as a final rule. This, however, is unlikely to occur until 2016 or early 2017.

The FAA does, however, have discretion as to when it commences enforcement proceedings, discretion that it has used for years to leave model aircrafts alone,[20] even though their flight arguably requires compliance with all the Federal Aviation Regulations' ("FARs") for airworthiness certification, pilots' licenses, and compliance with operating rules designed for airplanes and helicopters.[21] It would be good policy to exercise this discretion not to enforce the theoretical ban against DROPs who fly in conformity with the NPRM while it is being finalized. This would include obtaining certification from a private association that they have passed a knowledge test based on the NPRM's proposal.

C. The Private Pilot Requirement

In all of the 24 Section 333 exemptions granted as of early 2015, the FAA consistently insisted on at least a private pilot's license for DROPs.[22] It rejected arguments from ALPA that a commercial pilot's license should be required,[23] and also rejected proposals by some of the petitioners that less should be required, such as completion of a manufacturer or operator provided training program, or satisfactory completion of the private pilot knowledge test without having to satisfy the flight proficiency requirement.[24] There is every reason to expect that ALPA and others preferring high barriers to entry for microdrones will urge the FAA to modify the NPRM to reinstate a conventional pilot's license requirement.

As the NPRM recognizes,[25] requiring a private (or commercial) pilot's license is not an appropriate way to reduce risks associated with commercial microdrone flight.

> One thing we know for sure (and via the FAA's own research) Predator pilots with conventional licenses make more mistakes than Army operators without a pilot's license in flying their

20. NPRM, *supra* note 2, at 45-48 (discussing model aircraft regulation historically and under proposed rule).

21. *See* 14 C.F.R. §§ 21-121 (2010).

22. Drone Laws Blog, *All FAA Grant of Exemptions Under Section 333*, ANTONELLI LAW http://dronelawsblog.com/faa-grant-exemptions-section-333/ (last visited Apr. 19, 2015)

23. FAA, Grant of Exemption to Helinet Aviation Services, LLC, Exemption No. 11160, FAA Docket No. 2014-0785 at 3-5 (Feb. 2, 2015) (discussing ALPA objections to petition).

24. *Compare* FAA, In the matter of Trimble Navigation Ltd., Exemption No. 11110, FAA Docket No. 2014-0367 at 7 (grant of exemption Dec.10, 2014) (proposing no pilot-license requirement) with *id.* at 15 (imposing private-pilot requirement).

25. NPRM, *supra* note 2, at 99-107 (explaining why traditional pilot's license should not be required).

> UAVs,' says Missy Cummins, who teaches courses about drones at the Massachusetts Institute of Technology and Duke University. So making everyone get a license does nothing to improve safety.[26]

To evaluate that position, one needs to know what is necessary to get a private pilot's license.

An applicant for a private pilot's license must complete at least 40 hours of flight time, including 20 hours of dual instruction[27] from a certificated flight instructor ("CFI")[28] and undergo an adequate amount of ground instruction[29] to permit him to pass both a written ("knowledge") test and a Check Ride— the "practical test." The knowledge test is designed by the FAA and administered by private test centers designated by the FAA.[30] Check Rides are conducted by FAA inspectors or by designated pilot examiners ("DPEs")—CFIs specifically selected by the FAA to perform these delegated roles.[31] Candidates may not take the knowledge exam or the practical test until they are endorsed for both by their flight instructor.[32]

Specific knowledge and skills requirements are considered in sections VI and VII.A, which consider the relevance of these requirements for certification of DROPs.

Costs for obtaining a private pilot's license range from $6000—$10,000,[33] depending on the rate at which a candidate progresses. Instructors usually teach through flight schools, which range from small one to four-person operations to larger and more formal operations accredited by the FAA under Part 141.[34] Flight schools include aeronautical universities such as Embry-Riddle Aeronautical University,[35] Lewis University,[36] and Hillsboro Aero Academy.[37]

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

27. 14 C.F.R. § 61.109(a) (2010) (airplane); 14 C.F.R. § 61.109(c) (2010) (helicopter).

28. 14 C.F.R. § 61.193 (2009) (describing privileges of CFI). An "authorized instructor" includes a CFI, and a ground instructor for ground training. 14 C.F.R. § 61.1(b) (2015) (defining "authorized instructor").

29. 14 C.F.R. § 61.105(a) (2013).

30. Pilot Testing, FEDERAL AVIATION ADMINISTRATION, https://www.faa.gov/pilots/testing/ (last visited Mar. 24, 2015) (describing content of knowledge tests and knowledge test centers).

31. 14 C.F.R. § 61.47 (2013) (describing DPE).

32. 14 C.F.R. § 61.35(a)(1) (2013) (requiring instructor endorsement of preparedness for knowledge test).

33. *See* NPRM, *supra* note 2 (calculating cost of private pilot's certificate); 14 C.F.R. § 61.39(a)(6) (2015) (requiring instructor endorsement of preparedness for practical test).

34. *See* 14 C.F.R. § 141 (2013) (FAA-approved flight schools).

35. EMBRY-RIDDLE AERONAUTICAL UNIVERSITY, http://www.erau.edu/ (last visited Mar. 24, 2015).

36. *Unmanned Aircraft Systems, B.S.*, LEWIS UNIVERSITY, http://www.lewisu.edu/academics/unmanned-aircraft-systems/ (last visited Mar. 24, 2015).

37. *About Us*, HILLSBORO AERO ACADEMY, http://www.flyhaa.com/en/page/school (last visited Mar. 24, 2015).

III. Economics and Politics

In a truly rational world, licensing would be tightly integrated with the knowledge and skills required to perform the tasks of the occupation. That would, as section VI.A explains, require ongoing validation analysis and testing of the power of each licensing requirement to reduce one or more discrete risks experienced in the operating environment. Stall-prevention and recovery is practiced in flight training to reduce the obvious risks associated with stalling and losing control of an airplane. Practice autorotation is part of the helicopter training to ensure that rotor RPM does not decay so much after an engine failure that the helicopter loses the capacity to generate lift. Conversely, the FAA recognized, in early 2015, that knowledge testing on automatic direction finding using ADF equipment makes little sense, because few aircraft are equipped with ADF now, most ADF ground stations have been phased out, and ADF has been replaced by newer technologies for navigation.[38]

That is not, however, how most licensing decisions in a market-oriented economy and democratic political system are made. Rather, new licensing requirements are imposed by legislatures and administrative agencies based on a combination of experience-based instincts, mass political reaction to highly publicized mishaps, and efforts by existing occupants of the field to limit competition.

The likelihood of a close coupling between training and licensing requirements and operational reality is increased when practitioners are involved in defining and administering the requirements. In that respect, it is worth noting that almost everyone who participates in the flight training process for would-be pilots is himself a pilot, as often as not one involved in flying for a living in operations beyond flight training. Similarly, substantial fractions of the faculty in medical schools are comprised of practicing physicians. Law schools are much criticized, on the other hand, because of the relatively thin involvement of legal practitioners in determining the content of legal education, which is mostly designed by full-time, research-oriented, academics, who have left the practice behind—or who never had practice experience.

Involvement from active practitioners in setting and enforcing licensing standards, however, increases the likelihood of industry capture. Industry capture distorts the content of licensing requirements by simply making them the highest possible barriers to entry. The literature on occupational licensing suggests a variety of approaches to mitigate the risk of turning licensing regimes into cartels, but the best approach across the board is to insist that the

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38. Dan Namowitz, *Goodbye NDB and other outdated test questions*, AIRCRAFT OWNERS AND PILOTS ASSOCIATION (Jan. 29, 2015), http://www.aopa.org/News-and-Video/All-News/2015/January/29/FAA-posts-positive-airman-testing-changes-on-web-site (discussing removal of ADF questions from knowledge test).

proponents or defenders of licensing regimes and their training components demonstrate the validity of each basic requirement, in terms of its relationship to an operational risk. The analytical process is not unlike that imposed under Title VII on employer testing and job requirements.

There is little evidence of large-scale anticompetitive behavior in the aviation labor market yet.[39] To be sure, collective-bargaining agreements for pilots protect the job security and compensation arrangements for existing pilots from competitive pressures from new entrants. It is true that the 1500 hour requirement and the toughening of ATP knowledge testing ratchets up the barriers to entry by new pilots, but the evidence that existing pilot organizations pushed for these changes is thin.

In any event, advocacy of toughened requirements for pilot qualification almost always can be justified, as in so many other fields, by the enhanced safety that will result from the tougher requirements. Pilot groups such as the ALPA[40] and the agricultural pilots association have been advocating that microdrones be operated only by persons possessing traditional pilots licenses.[41] They justify their position based on arguments that requiring a pilot's license will enhance safety of microdrone flight.[42] It is also true, however, that the more demanding the requirements for microdrone operation are, the less of a threat they present to established manned aircraft operations and pilot jobs. The purpose of the advocacy may or may not be anticompetitive, but the effect certainly is. The balance between genuine safety concerns and anticompetitive efforts can be evaluated by the rigor with which the advocates of DROP licensing link specific licensing requirements to specific microdrone flight risks. The groups have not done much of that yet.

Furthermore, the credibility of a concern that more drones mean fewer airline pilot jobs or fewer helicopter charters is low. The putative anticompetitive instinct would come more from a loose sense of association with the pilot community in general, and a concern that, somewhere, in some part of the industry, drones might result in less demand for manned aircraft and therefore pilots.

39. *But see* Jack Nicas, *Man vs Drone: Some Pilots Fight Back Against Robots*, WALL ST. J. (Jan. 15, 2015) http://www.wsj.com/articles/man-vs-drone-some-pilots-fight-back-against-robots-1421347663 (quoting pilots who fear commercial competition from microdrones and sought private-pilot requirement in order to limit competition).

40. Federal Aviation Administration. Exemption No. 11160, Docket No. FAA-2014-0785 (Feb. 2, 2015) at 4 (FAA letter describing ALPA position that a commercial pilot certificate should be required).

41. *Id*. at 5 (describing NAAA opposition to petition).

42. *Id.* at 4 (quoting NAAA opposition to petition commenting that, "Just as manned aircraft pilots are required to undergo a rigorous training curriculum and show that they are fit to operate a commercial aircraft, so too must UAS operators. Holding a commercial certificate holds UAS operators to similar high standards as commercial aircraft operators and ensures they are aware of their responsibilities as commercial operators within the NAS. Medical requirements ensure they have the necessary visual and mental acuity to operate a commercial aircraft repeatedly over a sustained period of time.")

The alarmist argument, regularly advanced by ALPA, 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.[43] The engines for the 747 and 787 must withstand ingestion of an eight-pound bird.[44] A DJI Phantom weighs 2.6 pounds, and a DJI Inspire weighs 6.4 pounds.[45] The Cinestar 8HL weighs 6.72 pounds.[46]

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."[47]

Their incidence suggests that microdrone/manned-aircraft collisions would be unlikely:

> 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.[48]

IV. Dynamics of Compliance

Governments may adopt rules, but that does not necessarily alter behavior. Prohibition and the war against drugs—particularly as it concerns recreational marijuana use—come to mind. Whether the targets of the rules comply with them depends on how well the rules fit the economic

43. 14 C.F.R. § 33.76(b) (2007) (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%2033.76-1A.pdf.

44. 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 (2007), Table 1 (requiring tests with bird weight 8.03 pounds for engine inlet throat area greater than 6,045 square inches).

45. *See Phantom 2 Vision+ Specs*, DJI, http://www.dji.com/product/phantom-2-vision-plus/spec (last visited Mar. 24, 2015) and *Inspire 1 Specs*, DJI http://www.dji.com/product/inspire-1/spec (last visited Mar. 24, 2015).

46. *See CineStar-8 MK Heavy Lift RTF*, QUDROCOPTER http://www.quadrocopter.com/CineStar-8-MK-Heavy- Lift-RTF_p_1156.html (last visited Mar. 24, 2015)

47. *Airplane Turbofan Engine Operation and Malfunctions Basic Familiarization for Flight Crews*, Federal Aviation Administration, 23, https://www.faa.gov/aircraft/air_cert/design_approvals/engine_prop/media/engine_malf_famil.doc.

48. *UAS Safety Analysis*, EXPONENT 7 (Dec. 16, 2014), http://www.uasamericafund.com/assets/micro-uav-safety-analysis.pdf (hereinafter "MIT Bird Study").

circumstances of the targets, on whether informal behavioral norms of relevant groups encourage or discourage compliance, on the level of sanctions for noncompliance, and on the resources available to detect and punish noncompliance.[49] If, as many people believe,[50] drone operation should be regulated, and only persons with the requisite skills and safety orientation should be allowed to fly them, regulatory designers must pay attention to the logical relationship between rule content and verifiable risks. They also must understand the extralegal forces that can encourage compliance and work to mobilize those forces.

In many areas of human activity, actors adhere to norms that are not codified in law. Aviation is a prominent example.[51] Going to the back of the line in a grocery store or an airport boarding area are examples within almost everyone's experience. In other cases, these informal behavioral patterns have been translated into legal rules. In still other cases, a combination of legal mandates and prohibitions and private networks that encourage compliance and actually enforce them have grown up together. Aviation regulation, qualification of lawyers, physicians, and accountants are prominent examples of interrelated governmental and private forces. There are many other, examples as well.

Although economists identify a number of reasons why large groups are incapable of self-governance without intervention by legal obligation,[52] small groups, many quite informal, regularly govern themselves. "Most social order is not created by the State. There exists a vast ocean of social rules completely untouched by formal law."[53]

Sociology teaches that repeated interaction stimulates the creation and enforcement of social norms and compliance with them.[54] Governments may help create the preconditions by "yoking actors together into relationships of

49. *See infra*, note 53.

50. *Ipsos Poll Conducted for Reuters*, IPSOS (Jan. 29, 2015), http://www.ipsos-na.com/download/pr.aspx?id=14209 (reporting 42% oppose private ownership of drones).

51. *See, e.g.* Geoff Goodyear, *Focus on Safety: Experience Acquired at the Speed of Light*, VERTICAL MAGAZINE, Feb/Mar. 2015 (reviewing basic safety practices); *Pilots Resources: Air Safety Institut*e, AIRCRAFT OWNERS AND PILOTS ASSOCIATION, http://www.aopa.org/Pilot-Resources/Air-Safety-Institute (describing safety resources available to pilots through pilots' organization).

52. *See* Mancur Olson, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS (1965).

53. Bryan H. Druzin, *Planting Seeds of Order: How the State Can Create, Shape, and Use Customary Law*, 28 BYU J. PUB. L. 373, 375 (2014) [hereinafter *Druzin*]. *See also* Lawrence Lessig, *The New Chicago School*, 27 J. LEGAL STUD. 661 (1998); Ryan Goodman, *Beyond the Enforcement Principle: Sodomy Laws, Social Norms, and Social Panoptics*, 89 CALIF. L. REV. 643, 643 (2001); Cass R. Sunstein, *Social Norms and Social Roles*, 96 COLUM. L. REV. 903 (1996); Dan M. Kahan, *Social Influence, Social Meaning, and Deterrence*, 83 VA. L. REV. 349 (1997); Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 MICH. L. REV. 338, 346-47 (1997).

54. Druzin, *supra* 52, at 377-378.

repeated interaction through establishing legal obligations between them that will ensure this repetition."[55] Bryan Druzin offers the hypothetical example of the laws requiring the members of a small group to help one of their members prepare daily meals.[56] The resulting interaction will give rise to various informal rules guiding participation and sanctions for shirking.[57] He also offers as an example the emergence of the medieval Law Merchant, a series of customs that governed commercial interaction in business communities before commercial law emerged.[58] The state encourages such private arrangements simply by making private contracts enforceable through state institutions.[59] He offers some practical examples of how the state could engineer private governance:

> If the State considered it in the public interest that everyone take better care of their front yards, rather than concocting intricate laws requiring people to do so (something that would require unrealistic levels of monitoring and enforcement), the State could adopt the more deft approach of customary law cultivation. The State could harness the self-ordering potential of repeated interaction by requiring, for example, that the residents of a street collectively tend to one of the yards on the street each Sunday (the yard to be tended would change each week to ensure reciprocity). Non-compliance would be subject to a small fine. Instead of fabricating and enforcing a complex system of regulation, the State could simply impose a single legal obligation yet one that deliberately comprises an ongoing positive duty so as to bring private parties together into relationships of repeated interaction.[60]

In support of this hypothetical arrangement, he offers the example of "barn raising" in some rural communities: a phenomenon in which members of the community came together to help one member build a barn, supported by the expectation that the beneficiary would reciprocate.[61]

In the context of DROP certification, the FAA could play a similar role. The NPRM's testing requirement encourages a would-be DROP to be a member of an association similar to the American Association of Drone Instructors ("AADI")[62] and to obtain certification through the association.

55. *Id.* at 378.

56. *Id.*

57. *Id.* 388-390.

58. *Id.* at 390.

59. Druzin, *supra* 52, at 392.

60. *Id.* at 397.

61. *Id.* at 399.

62. *See* § C (describing proposed association of drone instructors).

V. Delegation

The idea of a private association working with the FAA to implement the NPRM does not involve handing off governmental authority to private actors.

Democratic political theory and the pragmatism of the administrative state collide when elected legislatures cede too much of their power to unelected administrative agencies or to private entities. The anti-delegation doctrine, rooted in the United States Constitution's separation of powers imposes limits on delegation of power by the United States Congress. In *Panama Refining Company*[63] and *Schechter Poultry,*[64] the United States Supreme Court struck down significant features of the National Industrial Recovery Act.[65] Congress had given up too much of its legislative power, the court said, by delegating rulemaking authority to a combination the National Recovery Administration, a federal agency, and private industry groups.[66] The particular action challenged in the *Schechter* litigation was the adoption, as a mandatory federal fair-competition-code, of live poultry codes developed by an industry association, which also was given administration and criminal enforcement responsibility.[67] Giving legislative power to private citizens and entities provided even less political accountability than giving it to agencies with an executive branch, the court reasoned.[68]

> [W]ould it be seriously contended that Congress could delegate its legislative authority to trade or industrial associations or groups so as to empower them to enact the laws they deem to be wise and beneficent for the rehabilitation and expansion of their trade or industries? Could trade or industrial associations or groups be constituted legislative bodies for that purpose because such associations or groups are familiar with the problems of their enterprises? And could an effort of that sort be made valid by such a preface of generalities as to permissible aims as we find in section 1 of title 1? The answer is obvious. Such a delegation of legislative power is unknown to our law, and is utterly inconsistent with the constitutional prerogatives and duties of Congress.[69]

63. *Panama Refining Company v. Ryan*, 293 U.S. 388 (1935) (invalidating, as overbroad, delegation of power to President to prohibit interstate transportation of "hot oil"—oil produced in excess of state quotas).

64. *A.L.A. Schechter Poultry Corp. v. United States*, 295 U.S. 495 (1935).

65. Act of June 16, 1933, c. 90, 48 Stat. 195, 196.

65. *See Panama Refining Company v. Ryan*, 293 U.S. 388 (1935) and *A.L.A. Schechter Poultry Corp. v. United States*, 295 U.S. 495 (1935).

67. *A.L.A. Schecter Poultry Corp.*, 295 U.S. at 524-526 (describing code, its origin, and the indictment of the challenger for violating it).

67. *Id.* at 537.

69. *Id*.

Although some commentators viewed the delegation doctrine as essentially obsolete,[70] the Supreme Court regularly used it to scrutinize statutory empowerment of administrative agencies.[71] As recently as 2013, the United States Court of Appeals for the D.C. Circuit used the delegation doctrine to invalidate a statute empowering Amtrak—a private, albeit government chartered—corporation to set performance standards for railroads, in conjunction with Department of Transportation:[72]

"Federal lawmakers cannot delegate regulatory authority to a private entity. To do so would be legislative delegation in its most obnoxious form."[73]

Accordingly, the force of the delegation doctrine is not so much that it regularly results in judicial invalidation of regulatory schemes as that it influences the design of such schemes, as legislation is being written. Apart from the responsibility of Congress, as well as the other two branches to honor the Constitution, there is no point in enacting legislation that will be struck down as unconstitutional.

But withstanding the delegation doctrine, Congress regularly gives substantial rulemaking authority to agencies, sometimes mandating that agencies adopt as governmental rules standards of conduct and performance developed initially by private bodies such as standard-setting organizations.[74] This is constitutional, so long as Congress "channels" agency rulemaking power by sufficiently specific criteria to limit its exercise. The legislative standards must be sufficiently specific to permit Article III courts to ascertain whether the agency has stayed within its delegated powers.[75]

70. *See Mistretta v. United States*, 488 U.S. 361, 413 (1989) (Scalia, J., dissenting)(observing that statutes have been invalidated under delegation doctrine only twice in U.S. history).

71. *See Mistretta* (upholding statute establishing federal Sentencing Commission); *Whitman v American Trucking Associations*, 531 U.S. 457, 472 (2001) (recognizing viability of delegation doctrine but rejecting delegation-doctrine challenge to EPA authority to set pollution limits).

72. *See Association of American Railroads v. United States Department of Transportation*, 721 F.3d 666 (D.C. Cir. 2013) (declaring statute unconstitutional), rev'd, *Department of Transportation v. Association of American Railroads*, 135 S.Ct. 1225 (2015) (remanding for determination of whether delegation doctrine permitted Amtrak to participate in setting standards for passenger train performance).

73. *Ass'n of American Railroads*, 721 F.3d at 670 (internal quotations omitted).

74. Updating OSHA Standards Based on National Consensus Standards; Head Protection, 77 Fed. Reg. 121 (Dep't of Labor June 22, 2012) (proposed rules) *available at* https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=23039 (showing national consensus standards incorporated into OSHA regulations through a table).

75. *American Ass'n of Railroads*, 721 F.3d at 670 (observing that delegation to administrative agency can survive delegation-doctrine challenge if an "intelligible principle" in the statute constrains agency legislative power).

Governmental rules derived from private sector standards of behavior are quite common. Even more common are rules developed based largely or entirely on private industry recommendations delivered through formal advisory committees or otherwise.[76] Indeed, the FAA traditionally has used such a process for developing most of its rules for airworthiness certification, operating rules, and pilot licensing.[77]

The FAA also relies on private individuals to implement and enforce its rules. Most of the detailed testing and inspection of an aircraft as part of the airworthiness certification process is performed, not by government employees, but by private manufacturers applying accredited processes.[78] Most flight tests for pilot's licenses are conducted, not by government employees, but by Designated Pilot Examiners ("DPEs").[79] Virtually all medical examinations for pilot certification are conducted by private physicians.[80] Many control towers at smaller airports are staffed, not by federally employed air traffic controllers, but by private contractors performing the same functions.[81]

These arrangements that involve broad delegation of rulemaking and rule-enforcement power by Congress initially to the FAA, and then to private sector decision-makers are widely accepted. It is difficult to find any argument that such an arrangement violates the delegation doctrine.[82]

There is no reason that mixed public/private mechanisms for drone regulation would be any more vulnerable to constitutional scrutiny.

But the realities of the microdrone marketplace and the context within which thousands of air vehicles will operate militate toward an even greater reliance on private entities for developing regulations and training of DROPs. The delegation doctrine may achieve increased prominence in shaping regulatory alternatives.

76. FEDERAL ADVISORY COMMITTEE ACT (FACA) MANAGEMENT OVERVIEW, G.S.A. http://www.gsa.gov/ portal/content/104514. (last updated Apr. 20, 2015)

77. ADVISORY AND RULEMAKING COMMITTEES, FAA (2015) *available at* http://www.faa.gov /regulations_policies/rulemaking/committees/documents/. ("We develop regulations using committees that include members of the aviation community and the FAA").

78. *Production Certificate Application and Approval Process*, FED. AVIATION ADMIN. (Aug. 6, 2014, 2:01 pm). http://www.faa.gov/aircraft/air_cert/production_approvals/prod_cert/prod_approv_proc/(describing FAA approval and audit of manufacturer processes).

79. 14 C.F.R. § 61.47 (2013) (describing DPE).

80. 14 C.F.R. §§ 67.405, 67.407 (2008) (describing examining physicians)

81. *See U.S. Contract Tower Ass'n.*, (last visited Mar. 24, 2015) http://www.contracttower.org/ (describing contract-tower program).

82. A Westlaw search on February 3, 2015 by co-author Perritt with the search term "delegation doctrine FAA private" produced no hits.

Already, the FAA has made suggestions[83] that recreational and hobbyist flight should be governed as a matter of law by model airplane association guidelines.[84] Under such suggestions, the private organization not only would develop the rules; they would enforce them by its membership expulsion power and a governmental regulatory probation against microdrone flight unless by one who is a member of the organization.[85]

That is not what the NPRM envisions; rather under it, the FAA retains the authority to make the rules and to prescribe the content of DROP tests. This follows the agency's longstanding practice for pilot certification. The FARs prescribe certain subjects that must be covered by flight training programs,[86] but the flight training programs themselves, stage testing, and certification of readiness for certain steps in the certification process, such as taking a knowledge test[87] or taking a practical test (checkride)[88] are done by private CFIs. We have no particular objection to it, but it's stylistically odd. The details of the curriculum flow from the FAA practical test standards, but are fleshed out by private flight schools, only some of which, under Part 141, are accredited by the FAA,[89] requiring their training materials, including instructional syllabi, to be approved in advance by the FAA.[90] The proliferation of microdrones necessitates a decentralized approach that relies more on private entities. For example, the law-abiding drone approach recommended by the authors of this article,[91] would, in some implementations, vest microdrone vendors with the responsibility of designing training programs and certifying satisfactory completion by DROPs.

83. Fed. Aviation Admin., *Interpretation of the Special Rule for Model Aircraft*, Docket No. FAA-2014-0396 (June 18, 2014), http://www.faa.gov/uas/media/model_aircraft_spec_rule.pdf at 11-12 (explaining requirement that model aircraft be operated within guidelines established by national community model aircraft associations).

84. The model aircraft community has vociferously opposed the guidance. *See AMA's Response to the FAA Interpretative Rule*, ACADMEY OF MODEL AERONAUTICS (last visited Mar. 24, 2015) http://www.modelaircraft.org /aboutama/ AMAInterpretiveRuleResponse.aspx .

85. *See Membership Manual 2015, Article V*, ACADEMY OF MODEL AERONAUTICS (last visited Mar. 24, 2015) http://www.modelaircraft.org/files/memanual.pdf (providing for expulsion of member for violating association rules).

86. 14 C.F.R. § 61.109(c) (2010) (specifying subjects of instruction).

87. 14 C.F.R. § 61.35(a)(1) (2013) (CFI endorsement for knowledge test).

88. 14 C.F.R. § 61.39(a)(6) (2013) (CFI endorsement for practical test).

89. 14 C.F.R. § 141.5 (2010) (requirements for approval).

90. 14 C.F.R. § 141.55(a)-(e) (2011) (requirements for approval of materials).

91. 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, Oct., 2014 at 2; Henry H. Perritt, Jr. & Eliot O. Sprague, *Reining in the Renegades*, VERTICAL MAGAZINE (Dec./Jan. 2014-2015).

VI. Content of Requirements

The NPRM sets forth the elements of knowledge that would be tested before one could be certified as a DROP. Those are summarized in section VII.A.1. Evaluating the content of these requirements should proceed from the need to assess the nexus between any training and certification requirements and the risks they are intended to mitigate—a process known to psychologists as "validation."[92]

The following section explains the validation concept and then applies it to the set of knowledge and skills that DROPs should possess, compared to the set of knowledge and skills needed by pilots of airplanes and helicopters.

In the NPRM the FAA embraced the idea of this kind of validation analysis:

The NPRM refers to a pre-NPRM petition submitted by the UAS America Fund that allows operation of microdrones weighing less than three pounds without requiring a conventional pilot's license.[93] The petition is the first of a series planned by the UAS America Fund advocating a segmented approach, based on aircraft size.[94] The NPRM invites comment on the segmented approach.[95]

The NPRM aligns the FAA with the UAV America Fund's position that existing private or commercial licenses are not the appropriate mechanism for assuring DROP qualification:[96]

> [T]he private pilot and commercial pilot certificates currently available involve substantial expense and hours of time learning actual flying skills within a passenger aircraft cockpit, but those skills do not have relevance to UAS operations, particularly for the micro UA category. Micro UA are operated from the ground, looking up. Skills learned inside an aircraft cockpit including those for in-flight maneuvers, aircraft systems, emergency procedures, and navigation are of minimal utility but impose significant burdens. The financial burden associated with micro UA pilots obtaining and maintaining a private pilot or commercial license would significantly impact business operations and will drastically reduce profits expected when forming a business, with no measurable benefit. There also will be a substantial burden on the FAA in issuing and maintaining pilot records for UA operators who will never fly a manned aircraft.[97]

91. *Test Validity*, WIKIPEDIA, (last visited Apr. 19, 2015).

93. Petition of UAS American Fund, LLC to Adopt 14 C.F.R. Part 107 to Implement Operational Requirements for Micro Unmanned Aircraft Systems, Docket No. FAA-2014-1087-0001 at 7-8 (filed Dec. 18, 2014) (petitioning for direct rulemaking rather than NPRM).

94. *Id*. at 4.

95. NPRM, *supra* note 2, at 52-54 (reporting earlier consideration of segmented approach and inviting comment).

96. *Id*. at 11-13.

97. *Id*. at pp.13-14.

Defining the knowledge and skills a DROP needs to fly a microdrone safely is but a specific instance of a more general challenge: understanding the implications of human/machine interaction as machines grow more intelligent and agile. Specifying necessary knowledge and physical motor skills is quite different for one operating a conventional bulldozer or construction crane, compared with the requirements for safe operation of an assembly line robot. Similarly, the skills necessary to make mathematical calculations on a slide rule are quite different from those required to operate a sophisticated electronic calculator or to use mathematics application software. The important judgment required to operate microdrones are quite different from those necessary to operate an airplane or helicopter, although the overlap increases as automation intensifies. The old emphasis on motor memory is marginalized by a new need how to use computer interfaces and how to deal with computer malfunctions.

The training and testing content requirements developed in the section can be imposed by regulation at the federal or state level; they can become an outline for detailed syllabi developed by flight schools; and they can form the core private certification as discussed in section VII.C.

A. Validation

The FAA has committed itself to risk-based analysis.[98] The NPRM reiterates that commitment and delivers on it. Risk-based regulation requires validation of regulatory requirements, establishing a nexus between each requirement and the risks it is intended to reduce.

Validation of occupational requirements is common in other fields. For example, the validation approach has called into question physical strength and agility requirements for public safety officers.[99]

> For instance, two federal courts have relied on the following 'expert' view of the differences between men's and women's physical abilities to justify sex-segregated physical activity for males and females:
>
> > [M]en are taller than women; stronger than women by reason of their greater muscle mass; have larger hearts than women and a deeper breathing capacity, enabling them to utilize oxygen more efficiently than women;

98. NPRM, *supra* note 2, at 34 (characterizing approach as "data-driven, risk-based").

99. *See* Ruth Colker, *Rank-Order Physical Abilities Selection Devices for Traditionally Male Occupations as Gender-Based Employment Discrimination*, 19 U.C. DAVIS L. REV. 761 (1986).

> run faster, based upon the construction of the pelvic area, which, when women reach puberty, widens, causing the femur to bend outward, rendering the female incapable of running as efficiently as a male.
>
> Not only do courts exaggerate the differences between men and women, implying for instance that no woman could run as fast as any man, but they consider only those physical traits traditionally valued by men. Yet, as commentator Lyn Lemaire noted, 'the importance of brute strength in many athletic activities is overrated. . . .' As this Article will explore, the emphasis on male physical traits prevails in the selection of firefighters and police officers.[100]

Ruth Colker urged greater scrutiny of actual job requirements rather than assumptions based on stereotypes.[101]

In *Harless*,[102] the Sixth Circuit recognized that a valid job analysis for a physical abilities test must focus on the physical demands of the job. The court found that the Toledo Police Department had never conducted a job analysis to determine the amount of physical strength or extent of physical exertion required for the job; instead, as the court found, the sole justification for the examination was the wholly inadequate 'intuition' of department officials.[103]

In *Albemarle Paper Co. v. Moody*,[104] the Supreme Court held tests administered by employers as part of the hiring process must be linked to the ability to perform a particular job or class of jobs.[105] The authoritative guidance on validation in the employment context is the EEOC's Uniform Guidelines on Employee Selection Procedures.[106]

Insisting on validation has utility outside the purely physical context. A Harvard law professor, writing in 1982,[107] proposed applying it to selection of law firm associates. She reviewed the traditional emphasis on law school pedigree and law school grades and the traditional justification that these criteria predict future performance as a lawyer.[108] She argued that these are poor predictors:

100. Colker, *supra* note 98, at 771.

101. Colker, *supra* note 98, at 788-795 (citing Berkman, 536 F. Supp. at 204).

102. 619 F.2d at 611 (1980).

102. *Id.*

104. 422 U.S. 405 (1975).

105. *Albemarle Paper Co.*, 422 U.S. at 426-427.

106. 29 C.F.R. § 1607.5 (1978) (describing criterion-related validity study, content validity studies, and construct validity study).

107. Elizabeth Bartholet, *Application of Title VII to Jobs in High Places*, 95 HARV. L. REV. 945 (1982).

> High grades and attendance at prestigious law schools are, at best, imperfect predictors of performance as a lawyer. Grades, for example, are designed to measure abilities that constitute a very small segment of the range of abilities involved in effective lawyering. Alternative selection schemes might measure additional attributes of at least equal importance. The firm might, for example, develop an assessment system that gave far less weight to law school examinations and more to performance on long-term written projects, trial and appellate advocacy skills, ability to work well with colleagues on cooperative projects, and qualities of aggressiveness, energy, and dedication to work.[109]

Pilot certification requirements enjoy a measure of validation absent from most other occupational licensing. The National Transportation Safety Board ("NTSB") investigates accidents and writes detailed reports on the serious ones. Its accident reports usually contain recommendations directed to operators and often to the FAA. In its report on the Colgan Airways crash near Buffalo,[110] for example, the Board made 25 new recommendations for changes to FAA operating rules, pilot training rules, and aircraft certification rules.[111] The Congress legislated a response,[112] requiring the FAA to implement NTSB recommendations regarding flight crewmember training.[113] It mandated new FAA rules that, among other things radically toughened the requirements for Airline Transport Pilot certificates,[114] specifically including a total of 1,500 flight hours.[115] The FAA responded with new rules.[116]

Furthermore, the credentials pilot employers insist that applicants for pilot positions produce certificates and logbooks. Pilot logbooks show experience in performing flight tasks; not grades on flight-school tests. Law firms do not routinely insist on the equivalent of logbooks for law graduates applying for associate jobs such as a log demonstrating how many cases the applicant has litigated or how many new business entities the applicant has set up.

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108. *Id.* at 1024.

109. *Id.*

110. NTSB, *Loss of Control on Approach, Colgan Air, Inc*., Feb. 12, 2009, NTSB/AAR-10/01, http://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1001.pdf (hereinafter "Colgan Air Report").

111. Colgan Air Report, *supra* note 109, at 156-159.

112. Airline Safety and Federal Aviation Administration Extension Act of 2010, Public Law 111-216, 124 Stat. 2348

113. *Id.* at § 208.

114. *Id.* at § 217.

115. *Id.* at § 217(c).

116. 78 FED.REG. 66261.

Also, pilot hiring decisions are generally based on flying with the candidate. In these pre-hire flights, the operator evaluates a number of pilot skills and attributes only some of which are part of formal pre-license training and evaluation requirements. Similarly, law firms, especially through summer clerkship programs, evaluate candidate attributes that are not part of law-school curriculum or tested on the bar exam.

The validation question is to what degree these hiring criteria can be exported backwards into formal requirements for training and testing.

The point is not that courts routinely should insist upon Title-VII level validation analyses; the point is that the validation concept should inform policy judgments about rule content for microdrone operation. It also may be appropriate, if the policy process goes awry in this regard, if drone operators were required to have traditional pilot's licenses, for example, for lack of validity justification to signify irrationality and arbitrary-and-capricious decision-making, obligating a reviewing court to invalidate such requirements under the Administrative Procedure Act.[117] The literature suggests that courts hearing challenges to the anticompetitive effect of license requirements insist on objective empirical evidence that the content of the certification requirements, as applied, actually provides net consumer benefits.[118]

B. Knowledge

The knowledge elements included in the testing required by the NPRM for DROP certification[119] honor the validation approach. Requiring a manned aircraft pilot's license does not; some of the requirements overlap, but too many diverge.

1. Principles of Flight

Microdrone DROPs should understand certain basic principles of physics, including the idea that acceleration depends on the net force applied to an object divided by its mass, that kinetic energy is one-half times mass times velocity squared, and that in collisions or crashes, kinetic energy must be absorbed by deformation of materials, including human body parts. DROPs need only limited knowledge of aerodynamics, structures, and aircraft stability and control. They should understand: the basics of lift and drag, how lift is generated by rotors, how multirotor drones introduce pitch, role, and yaw forces by varying thrust asymmetrically, and how thrust varies with RPM.

117. 5 U.S.C. § 706(2)(A).

118. David A. Hyman & Shirley Svorny, *If Professions are Just "Cartels By Another Name" What Should we do About it?*, 163 U. PA. L. REV. 101 at 118.

119. *See* section 1.

They also need to understand the basic functional components of a microdrone control system: how the DROPCON transmits DROP control inputs through the control link, how the receiver on the drones receives them and feeds them into the computer logic of the control board which combines them with inputs from the onboard GPS receiver, accelerometers, magnetometer, and altimeter and translates them into signals that the power distribution board can use to meter electrical current to each motor.

They should understand the basics of wind, not so much how it is produced by meteorological forces, but the fact that airborne aircraft move with the wind without experiencing crosswind, headwind, or tailwind. Crosswinds, headwinds, and tailwinds exist only with reference to the ground. In this context, they should understand and be able to compute wind limitations based on arithmetic computation of the microdrone's maximum speed capability, compared with the wind components. In other words, a drone that is capable only of achieving 20 knots will not be able to maintain its position over the ground when the wind is blowing from any direction at 25 knots.

They also should understand the rudiments of autorotation by a variable pitch rotor, so that they understand why a fixed pitch multirotor microdrone is incapable of autorotation. Unlike a helicopter pilot, a DROP can do nothing to set up an autorotation if the propulsion system fails. After a power failure, not only will the drone's rotors stop generating lift, causing the drone to fall at its terminal velocity; it is likely to tumble because its rotors no longer produce the stabilization forces to maintain its orientation.

DROPs should understand the basics of lithium polymer battery chemistry, so that they can anticipate when battery capacity is likely to be exhausted, and the risks associated with mishandling batteries.

Unlike airplane pilots, microdrone DROPs do not need to know the details of airplane performance, stability and control, such as the relationship between angle of attack and stalls, the dynamics of spins, how control surfaces work by changing the camber of an airfoil, or how to calculate weight and balance. They do not need to know the effect of density altitude on aircraft performance. Unlike helicopter pilots, they do not need to understand effective translational lift, translating tendency, loss of tail rotor effectiveness and the need for anti-torque control.

2. FARs, with an Emphasis on Airspace Classification

Unlike airplanes and helicopters, microdrones operate in confined local spaces, generally less than 500 feet above the ground, and within the line of sight of the DROP not more than about a thousand feet away. Apart from safety guidelines, their performance will not allow them to do much more than that; even though some microdrones are capable of flying much higher, limitations on control-link range apply to the vertical dimension as well as a horizontal one, which also limits height.

DROPs, unlike pilots, do not need to master the many parts of the FARs that pertain to long-distance flight. Nor, since line of sight cannot be maintained in instrument meterological conditions ("IMC"), do they need to know those parts of the FARs that pertain to instrument flight rule ("IFR") operations.[120]

They do, however, need to know preflight and flight planning requirements pertinent to a particular operation. Essentially, there needs to be an understanding of obligations to make sure that the aircraft is in flying condition before launch, how to select an operating area that minimizes risk, and the flight techniques for safe operation within that area. They must appreciate the need not to overfly people, and how they usually can get the imagery they want of people, animals, and objects by positioning the drone at an offset angle of about 45° rather than flying directly overhead. They also need to know how airspace is defined and the limitations associated with different classes of airspace around busier airports, including radio communication requirements. Finally, they should know what to expect of manned aircraft, including the different height limitations imposed on airplanes and helicopters, and typical approach and departure flight profiles for both types of aircraft.

3. Radio Communication

Because safe operation of drones depends on the integrity and security of the radio frequency ("RF") links that connect drone with DROP, DROPs should have a basic understanding of how RF communication works. In particular, they should understand modulation, signal propagation, encryption, and video encoding.

i. Modulation in General

Communicating information by radio requires that the information be superimposed on a carrier signal at the higher frequencies that permit it to be propagated through space. The signal containing the information, whether a series of bytes representing control inputs from the DROP to the drone, or video transmitted back from the drone to the DROP or an associated photographer, varies at a much lower frequency than is necessary for the carrier signal. Superimposition of the lower frequency information on the carrier signal is called *modulation*.[121]

A carrier signal can be modulated by adjusting its amplitude (strength), shifting its frequency slightly, shifting its phase, or a combination of all three. Current modulation techniques use a combination to get the highest possible efficiency and noise immunity. But simpler techniques better illustrate the process. The simplest of all, and therefore the first to become a commercial reality is the superimposition of a Morse code signal on a carrier, resulting in radiotelegraphy. In this form of modulation, the carrier amplitude is modified by the Morse code signal.

120. 14 C.F.R. § 91.167-91.193.

121. *See generally* Modulation, WIKIPEDIA (last visited Mar. 24, 2015), http://en.wikipedia.org/wiki/Modulation.

Morse code represents alphanumeric characters and basic punctuation marks by a series of dots and dashes.[122] A "P" for example, is represented by the pattern dot-dash-dash-got.[123] To modulate a carrier so that the P is transmitted involves adjusting amplitude crudely, between zero and maximum. Thus transmitting a P involves turning the signal on briefly for the dot, turning it off, turning it on for a somewhat longer period to represent the first dash, turning it off, and then on again for the same period to represent the second dash, turning it off, and then turning it on again briefly for the final dot. Frequency shift keying, developed somewhat later, provide better noise immunity. It involves shifting the carrier frequency slightly lower for a dot, slightly higher for a dash, and leaving it alone for the spaces.

When the information comprises changing values, such as speech, music, or full motion video in analog, the modulator adjusts the carrier amplitude or frequency or both continuously, in step with the value of the information signal. When similar information is encoded digitally, as his own mostly the case now with current technology, the modulation of the carrier with the zeros and ones of the bits comprising the digitized signal take modulator designers back to Morse code days. The value changes in the information signal are vastly greater for a digitized video signal than the frequency with which the dots dashes occurred in 1920-era radiotelegraphy, but the modulation principles are the same.[124]

A principle from automatic control theory known as the *Nyquist criterion* expresses the common-sense idea that a carrier signal cannot be modulated at a rate faster than it is changing its self.[125] In other words, one cannot modulate a 1 MHz carrier with a 2 MHz information signal. In particular, the Nyquist sampling criterion[126] says that the carrier frequency must be at least twice that of the modulating signal. That means that frequencies for DROP-to-drone communication must be higher, in proportion to the rate that information needs to be transferred to or from them. A full-motion video signal in uncompressed format requires 2.9 gigabits per second to deliver all the necessary information in real time.[127] That means that the carrier signal must be at least twice that or 5.8 Gigahertz. Some degree of compression is necessary to reduce the bandwidth requirements.

122. Morse Code, WIKIPEDIA (last visited Apr. 20, 2015), http://en.wikipedia.org/wiki/Morse_code

123. *Id.*

124. *See* NATIONAL ASSOCIATION FOR AMATUER RADIO, HANDBOOK FOR RADIO COMMUNICATIONS Ch. 12 (2003) (explaining different modulation techniques). [hereinafter "ARRL Hanbook"] (explaining different modulation techniques).

125. Nyquist criterion, WIKIPEDIA (last visited Apr. 20, 2015), http://en.wikipedia.org/wiki/Nyquist_criterion

126. Nyquist–Shannon sampling theorem, WIKIPEDIA (last visited Mar. 23, 2015), http://en.wikipedia.org/wiki/Nyquist%E2%80%93Shannon_sampling_theorem.

127. Video Bitrate calculation for uncompressed video, STACK OVERFLOW (last visited Mar. 23, 2015), http://stackoverflow.com/questions/24163432/video-bitrate-calculation-for-uncompressed-video.

Another theoretical principle, this one from information theorist Claude Shannon at MIT,[128] declares that the bandwidth required for a signal increases in proportion to the rate the signal transmits information. Thus a video signal requires more bandwidth than a Morse code signal.

The combination of the Nyquist criterion and the Shannon principle drives the carrier frequencies necessary for drone RF signals upwards. FCC licensing groups them in the 2.4 GHz and 5.8 GHz bands.[129]

ii. Spread Spectrum Modulation

Spread-spectrum technology utilizes brief transmissions of the modulated carrier on each of several frequencies, as many as 100 in some implementations.[130] It was developed initially by military and naval forces to improve communication security and minimize interference.[131] Because different pairs of transmitters and receivers use different sequences of frequency selection, many communications can occur simultaneously on the same set of hopping frequencies without interfering with each other. FCC specifications for spread spectrum equipment, such as that used for Wi-Fi in the 2.4 GHz band, sets strict limits on transmitter power in order to reduce the potential for interference. That, combined with the relatively short range of such transmitters at these frequencies, makes spread spectrum Wi-Fi extremely flexible, thus allowing dozens of homes in the same neighborhood to have their own Wi-Fi networks without interfering with each other. For example, the 802.11g Wi-Fi standard uses spread spectrum modulation in the 2.4 GHz band and has a maximum net data rate of 54 megabits per second.[132]

It is the case, however, that, as the number of transmitters and receivers increase attempting to use the same set of hopping frequencies, the potential for interference and reduced speed of communication transfer occurs. Congestion also occurs when some of the signals have high bit rates, such as that required for video imagery. In the microdrone context, using the same spectrum band for

128. C.E. Shannon, *A Mathematical Theory of Communication*, 27 BELL SYSTEM TECH. J. 379 (1948) *available at* http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf.

129. *See* Federal Communications Commission, Infrastructure (U-NII), Devices in the 5 GHz Band, First Report and Order 3-14 (Apr. 1, 2014), http://www.fcc.gov/document/5-ghz-u-nii-ro (reviewing decisions allocating spectrum for WiFi).

130. Spread Spectrum, WIKIPEDIA (last visited Apr. 20, 2015) http://en.wikipedia.org/wiki/Spread_spectrum

131. *See* ARRL Handbook, supra note 124, at 12.54 (explaining history of spread spectrum modulation).

132. *See* Bradley Mitchell, *Wireless Standards 802.11a, 802.11b/g/n, and 802.11ac: The 802.11 Family Explained*, ABOUT TECH http://compnetworking.about.com/cs/wireless80211/a/aa80211standard.htm (explaining specifications for different Wi-Fi standards).

video downlink as well as for the control link significantly increases the potential for interference, because the video signal has such a high information transfer rate, that it uses more of the available bandwidth and can occupy most or all of the spread spectrum hopping frequencies, thereby crowding out the control signal. If GPS-based flight planning software is used to control drone position, the potential for interference increases further. Accordingly, the better implementations put control-link signals and telemetry on one band, either 2.4 GHz or 5.8 GHz and video downlink signals on the other.

iii. Propagation

Radio signals move through space differently depending on their frequency and wavelength. Wavelength and frequency are inversely related: the higher the frequency, the smaller the wavelength.[133] For example, a 7 MHz frequency has a wavelength of about 40 meters, and a 144 MHz signal has a wavelength of about 2 meters. Still higher frequencies have still shorter wavelengths; signals in the 2.4 GHz band have a wavelength of 12.5 centimeters.[134]

Propagation differences exist because the electromagnetic energy comprising radio signals interacts with the molecules in the earth and the atmosphere differently depending on their wavelengths. Also, they interact differently depending on whether the molecules in the atmosphere are ionized, as they are in the ionosphere.[135]

In general, and to oversimplify somewhat, very low frequency signals, such as those used to communicate with U.S. Navy submarines, penetrate the earth and are attenuated by the atmosphere. Medium frequency signals, such as those used for the AM broadcast—515 to 1600 kHz—do not penetrate the earth well, but they travel further in the atmosphere and, at night, when ionization of the atmosphere is greater, they bounce off the ionosphere and are capable of greater range. High-frequency signals, from 1.5 MHz to 30 MHz, bounce off the ionosphere at different levels depending on time of day and frequency. This reflection produces a phenomenon known as "skip" which allows long-range global communication by these frequencies. VHF signals, those from, 30 to about 200 MHz, and UHF signals, from 200 MHz to about 1 GHz, penetrate the ionosphere and do not skip. They are useful only for line of sight communication. Above 1 GHz, the bottom of the microwave region, signals are useful for line of sight, but they are progressively attenuated by the atmosphere and precipitation in the atmosphere, with more attenuation as the frequency increases. They also are more likely to be reflected by ground objects such as foliage, structures, and vehicles.[136]

133. *See* ARRL Handbook, *supra* note 121, at 21.1 (explaining fundamentals of radio waves).
134. *See* ARRL Handbook, *supra* note 121, at 21.2 (giving formulas for converting between frequency and waveleng; summarizing properties of different wavelengths).
135. *See* ARRL Handbook, *supra* note 121, at 21.2-21.6 (explaining how atmosphere interacts with radio waves to produce different propagation characteristics).
136. *See* ARRL Handbook, *supra* note 121, at 21.4-21.6 (text box summarizing different propagation characteristics of different wavelengths).

Thus a 2.4 and 5.8 GHz signal are similar in their line of sight properties, but are different, in that the 5.8 GHz signal suffers more attenuation by the atmosphere and objects.

4. *Weather*

Microdrone DROPs do not need the same level of understanding of weather phenomena as do manned aircraft pilots. They fly their microdrones within the line of sight, mostly in daytime, and in low-wind conditions. They do not need to understand specific flight planning weather products,[137] because they can see for themselves how far they can fly their microdrones without losing sight of them because of obscuration or cloud cover. They do not need to understand weather prognosis beyond what is available from general audience print and electronic media; they can see for themselves whether the latest forecast is proving correct.

Their practical knowledge of what may make their vehicle uncontrollable will cause them not to attempt flight in adverse weather conditions. The circumstances for manned aircraft flight are entirely different. For one thing, they occur over ranges of dozens or hundreds of miles, where the weather is likely to be quite different from that at the takeoff point. For another, manned aircraft pilots need to know the boundaries between visual flight rules ("VFR")[138] and IFR,[139] so that they can operate only within the limitations of their aircraft and their pilot certificates. Moreover, much of aviation using manned aircraft necessitates flying in an adverse weather conditions, in which pilots must know how to control the aircraft by reference to instruments only, must understand the complex system of air traffic control (ATC) IFR clearances,[140] and must know how to avoid icing, turbulence, and thunderstorm activity even when they are legally operating under IFR in restricted visibility.

5. *Automation*

Designing appropriate knowledge and skills requirements for automated cockpits is challenging the FAA.[141] The automation of flight systems of man aircraft has accelerated greatly since the deployment of the first rudimentary autopilot in 1923. Now, pilots of even the lowest level of general aviation aircraft routinely use multi-axis autopilots, and full "glass panel" displays, in which basic flight information such as airspeed, altitude, direction of flight,

137. FAA, Airman's Information Manual 5-1-1.
138. 14 C.F.R. §§ 91.151-91.161 (visual flight rules).
139. 14 C.F.R. §§ 91.167-91.193 (instrument flight rules).
140. 14 C.F.R. § 91.173 (requiring ATC clearances).
141. *See* Lane Wallace, *Flight School: Glass Panel Training*, FLYING (June 29, 2010), http://www.flyingmag.com/pilot-technique/new-pilots/flight-school-glass-panel-training (explaining differences in training for two types of cockpit displays).

aircraft pitch attitude, bank angles, and rates of turn, climb, and descent are displayed digitally on a screen, rather than by separate "steam gauges," in which the same basic information was presented an analog form, usually by the position of a needle.[142]

Glass panel instrumentation and the computers that drive them offer new capabilities that reduce pilot workload. For example, a pilot flying an instrument approach can select the approach from a database stored in the system and fly it by hand with reference to a moving map display, or couple it to the autopilot and let the autopilot fly the airplane down to certain minimum altitudes.

Because the systems reduce pilot workload and improve the accuracy with which navigation procedures can be executed, they potentially reduce risks. On the other hand, there is growing recognition in the aviation community that cockpit automation also adds new risks. First, overreliance on automation allows pilot skills related to manual flying to atrophy, or that a pilot confronted with a system anomaly or failure is less prepared to take over and maintain safe flight.

Second, the systems themselves and their interfaces are complicated, typically involving dozens of menus arranged in hierarchies that are not always intuitive. To make effective and safe use of such systems, pilots must be able quickly to change what is displayed on the screen, enter new data, and confirm its accuracy. The number of choices and their accessibility on different menus easily can overwhelm a pilot who is not completely familiar with that particular system or in stressful situations, such as an emergency. Fumbling with or misunderstanding automated flight control systems is what happened in the Asiana crash in San Francisco,[143] and the Air France crash in the Atlantic Ocean.[144]

The debate about how to change training, knowledge, and skills requirements to reduce risks of these types of accidents has not yet crystallized into regulations. Some steps have been taken to require additional training of Airline Transport Pilot for aircraft upsets, emphasizing quick recognition of an unsafe condition such an incipient stall, and immediate appropriate responses.[145]

Dealing with the problem of the human interface with highly automated systems, however, has been less comprehensive and robust, limited to a few changes in certification requirements for avionic systems.[146]

142. *See The Great Debate: are glass cockpits better?*, AIR FACTS (Jan. 3, 2012), http://airfactsjournal. com/2012/01/the-great-debate-are-glass-cockpits-better/ (online debate among pilots about merits of glass panel displays).

143. BOARD MEETING: CRASH OF ASIANA FLIGHT 214 ACCIDENT REPORT SUMMARY, NAT'L. TRANSP. SAFETY BD., NTSB IDENTIFICATION: DCA13MA120 (June 24, 2014) *available at* http://www.ntsb.gov/_layouts/ntsb.aviation/brief.aspx?ev_id=20130707X83745&key=1&queryId=975add42-dbf9-4b6d-a88a-8c2be55551d0& pgno=2&pgsize=50.

144. *See* William Langewiesche, *The Human Factor*, VANITY FAIR (Oct. 2014) (probing factors that caused Air France crash).

145. 14 C.F.R. § 61.156(b)(1)(i)-(ii) (2015) (requiring upset and stall recovery training).

146. *See* VITA Technologies, DO-178C: Improved certification for cost-effective

One reason it is so difficult to develop appropriate training and testing requirements for automated cockpits is that the way in which information is displayed, and the way in which systems are controlled varies significantly between different commercial products. Building specific product characteristics into governmentally imposed regulatory requirements limits competition and inhibits innovation. This is a relatively new problem. While the cockpit layouts differ significantly between an Airbus 340 and a Boeing 767, and those of a Diamond Twin Star differ significantly from those of a Mooney M20, the similarities are greater than the differences. The pilot has a stick, yoke, or joystick to control pitch and bank of the airplane, rudder pedals to control yaw, and some kind of throttle or fuel control lever to control thrust.

The challenges for regulation related to cockpit automation are considerable, and aviation safety depends upon appropriate FAA and vendor responses.

For microdrones, however, the problem is qualitatively different in two respects. First, safe control of the aircraft depends entirely on the correct operation of automation systems. For automatic hover, or autonomous return to home, no DROP input is involved. The system does it entirely on its own, directly controlling the propulsion and control systems on the aircraft. System malfunction is not something the DROP can correct for by manually flying the aircraft.

Second, in some respects, autonomous control features reduce necessary DROP skills. Hovering a helicopter is quite difficult for primary flight students. Usually they do not master it until eight or nine hours of flight instruction. This is not the case with microdrones, especially those with autonomous hover capability. Onboard accelerometers, magnetometers, and GPS receivers and computers automatically send appropriate control inputs to the electric motors powering the rotors to keep the vehicle stationary over a particular point on the ground. The DROP need do nothing; indeed, on the DJI Phantom and some of its competitors, automatic hover occurs whenever the DROP releases the controls altogether.[147]

What this means for knowledge, skill, and training requirements is that (1) the DROP must be completely familiar with how the flight control systems work and how his inputs influence their operation; (2) he must know about the types of malfunctions that may occur, such as loss of a GPS signal, how the systems will respond, and whether he can provide any control input that will render the aircraft safe in such circumstances; (3) how inspections before and after flight can reduce the likelihood of system malfunction and (4) the need to be attentive to software and hardware upgrades provided by the vendor when he becomes aware of system

avionics systems, http://vita.opensystemsmedia.com/articles/do-178c-certification-costeffective-avionics-systems/ (explaining trends in certification of avionics systems).

147. *See* DJI, PHANTOM 2 USER MANUAL V1.4 at 16 (2015) (explaining that vehicle automatically hovers when sticks are centered).

deficiencies. These requirements are not altogether different for those pilots of manned aircraft, but they involve different kinds of risks and different kinds of responses.

6. *Drone Systems, with an Emphasis on Controls Links*

Microdrones are highly automated. Unlike in an airplane or helicopter, control inputs by the operator do not directly move control surfaces, change pitch, or increase torque. Instead, DROP control imports are fed through the computers on the control board, which combines them with sensor data about aircraft position, speed, and direction of flight and decides what adjustments should be made to motor current to implement the DROP commands. A DROP, far more than a pilot, needs to understand the basic operation of the control systems on the microdrone.

The DROP also must understand the steps to calibrate the magnetometer and the GPS navigation system before the microdrone is launched. The magnetometer must learn which way is north, its orientation when it is level with respect to the earth, and its launching position so it knows where "home" is. If the vehicle is not calibrated accurately before it is flown, it may be uncontrollable, and its return to home feature may take it to an unpredictable place.

For the Phantom, GPS calibration involves ensuring that the vehicle is sitting level when power is applied and waiting until its lights flash in a particular pattern. Magnetometer calibration involves picking the vehicle up and spinning it several directions until a different pattern of lights is complete. The calibration process differs from model to model, and the DROP must understand it for the particular model he is operating.[148]

7. *Drone Emergency Procedures*

The emergency procedures that DROPs must understand are different from those that pilots must understand. Pilots must understand how flight may be continued safely if an engine fails, through autorotation in a helicopter, and by maintaining a speed above stall speed in an airplane while it glides to a safe landing.[149] DROPs do not need to know this because microdrones are unlikely to experience engine failures and, in any event, can neither glide nor autorotate. Pilots need to understand the dangers of flying into weather conditions that reduce visibility; DROPs need not, they only need to understand the NPRM's requirement that they fly only when visibility is good enough to maintain line of sight.[150]

148. *See e.g.*, DJI, PHANTOM 2 USER MANUAL V1.4 at 23 (2015) (specifying calibration process).

149. *See* FAA, *Private Pilot Practical Test Standards for Rotorcraft-Helicopter* (July 2005) (requiring demonstration of proficiency in autorotation).

150. NPRM, *supra* note 2, at § 107.31 (limiting operations to line of sight).

DROPs do need to know how to deal with loss of the wireless control link and with battery exhaustion.[151] Pilots do not need to know this because airplanes and helicopters have neither control links nor battery-powered propulsion systems.

C. Skills

A baseline justification for any skills training and testing should be that that the student should be able to practice each knowledge element. If a knowledge element is justifiable by its relationship to a discrete risk, it does little good unless a DROP can put it into practice. If a bit of knowledge need not be practiced, it cannot be justified as a requirement.

To satisfy skill requirements for certification, DROP candidates should be able to demonstrate that they consistently can keep the microdrone under control, make it go where they want it to, and avoid objects that might interfere with flight or the integrity of the control link, or suffer injury or damage. As with any skill, proficiency requires practice. The NPRM leaves the details of skills training and testing up to the institutional operator.[152]

Based on the co-authors' experience in flying airplanes and helicopters, on co-author Sprague's experience giving flight instruction, on their experience in flying various models of microdrone, and advising others on flying them, a total of 10 hours seems the right level of experience. Ten hours of total flight time equates to about 30 flights of a Phantom-class microdrone – more flights for one with less endurance. That is surely enough to master procedures including calibration, operation of the automation features, keeping the drone in sight, and maintaining control of it. Indeed, 30 supervised flights in an airplane or helicopter is about the level required of a private pilot candidate, because instructional and student solo flights usually take about an hour each.

Beyond accumulating the requisite total flight time, DROP candidates should practice and demonstrate their skill at handling particular situations. They should be able to judge how high 500 feet above the ground is, and how far away 1000 feet is, without having to rely on telemetry from the microdrone. They should be able to maintain control of the microdrone regardless of which way it is pointing. Later models of the Phantom and the Inspire have an operating mode that is indifferent to drone orientation with respect to the DROP, [153]but in case he flies a model without this feature, or the feature doesn't work properly, he needs to be able to apply control imports as though he were aboard

151. NPRM, *supra* note 2, at 79-80 (discussing mitigation of loss-of-control risk).

152. NPRM, *supra* note 2 at 100-103 (explaining decision not to require skills testing and aeronautical experience).

153. *See* DJIPhantom, *Intelligent Orientation Control* (Apr. 21, 2015) http://www.djiphantom.co/category/intelligent-orientation-control.html (explaining how Phantom can be configured to accept commands relative to DROP's position rather than relative to vehicle orientation).

the aircraft, facing in whatever direction the drone is pointing. That might mean pushing the cyclic stick forward to cause of the drone to go to the DROP's left, if the drone has yawed 90 degrees to the left, or pushing the cyclic forward to make the drone come back toward him if its nose has yawed 180 degrees.

He also needs to demonstrate safe reactions if the drone flies behind an object obstructing his view of it. He should show his proficiency in triggering return to home or disabling return to home if he wishes to regain manual control.

He should practice and demonstrate mastery of various modes of flight and triggers for them, such as switching between attitude and GPS mode, setting height and range limitations, programming a flight plan on a map display and modifying it or interrupting it while the drone is executing the plan.

When DROPs operate the camera as well as flying the drone, they should demonstrate proficiency in performing both tasks while remaining within line of sight and within altitude and distance limitations.

D. Observers

The NPRM wisely omits the requirement, imposed in all the section 333 exemptions, for an observer separate from the DROP.[154]

The co-authors have flown as both pilots and copilots in several different types of airplanes and helicopters and have flown and observed flights of various models of microdrone. In an airplane or helicopter, it is convenient to have a second pilot, or even a non-pilot passenger. The second person can help keep a watch for potentially conflicting traffic, enter radio frequencies, activate flaps and other systems, and if properly qualified and upon request of the pilot take over the controls while the pilot performs a non-flying task such as shedding a jacket or entering navigational data.

For microdrone flight, an observer performs no useful function—except keeping the DROP company. If the DROP loses sight of the aircraft, the fact that the observer can still see it makes little difference. It is not physically possible for two people to manipulate the controls on the small DROPCON used for microdrones. It is difficult for a second person to get a clear view of the DROPCON screen without putting his head in the DROP's way.

VII. A proposal for DROP certification

A. Basic Requirements

Requiring certification of DROPs provides a number of advantages. It is a mechanism for delivering training and assuring a certain level of knowledge and skills that can improve safe operation of drones. It permits the FAA to know

154. NPRM, *supra* note 2, at 63 (discussing visual observer and emphasizing that none is required).

who is flying them. It also gives the FAA leverage to enforce its regulations, because it gives the DROP an asset—his DROP certificate—that he must retain in order to keep flying. Being able to take adverse action against a certificate holder who violates the rules puts the FAA in a much stronger enforcement position then if it must track down initially unknown violators and impose civil penalties against them.

It is also true, however, that any form of certificate requirements imposes a barrier to entry by DROPs that does not now exist. Thousands of individuals have purchased microdrones and are flying them, many undoubtedly for commercial purposes. If they are not deterred by the FAA's outright ban, they are unlikely to comply with a new requirement that they stop flying until they get DROP certificates. Some of them will, but not all.

This potential for widespread noncompliance is reduced by the NPRM's certification strategy that adjusts the level of requirement for certification according to the level of drone to be flown under a particular class of certificate. The UAS America Fund, it its petition for rule making,[155] presents a good idea: for very small microdrones, no significant training or testing would be required.[156]

If more is thought to be necessary, DROPs could be required simply to register with the FAA or to take a short online quiz administered by the vendor. The quiz would not be difficult; it would be comparable to a typical driver's license written test, designed to assure basic knowledge of the rules and of safe practices. For heavier, more complex drones with higher performance in terms of range, altitude, speed, more knowledge and skills training and testing would be required. At the high end, the requirements would be modeled on the requirements for manned aircraft pilot certificates, perhaps at the commercial level, but with content tailored to the risks involved in machodrone flight rather than those associated with airplane or helicopter flight.

However DROP training, testing, and certification requirements are imposed, policy makers must determine the content of the requirements. The following two subsections summarize the NPRM's requirement for knowledge testing and take existing requirements for private-pilot skills and annotates them to make them suitable for DROP certification.

155. Petition of UAS America Fund, LLC ("UAS Fund") to Adopt 14 C.F.R. Part 107 to Implement Operational Requirements for Micro Unmanned Aircraft Systems (Dec. 18, 2014), http://www.regulations.gov/#!documentDetail;D=FAA-2014-1087-0001 [hereinafter "UAS America Fund Petition"].

156. UAS America Fund Petition, *supra* note 155 at 14 (describing knowledge test proposal as only test requirement).

1. Knowledge Requirements

This subsection sets forth the black-letter knowledge requirements from the NPRM. These requirements track the discussion of knowledge requirements in section 0 well.

(1) Applicable regulations relating to small unmanned aircraft system rating privileges, limitations, and flight operation;

(2) Airspace classification and operating requirements, obstacle clearance requirements, and flight restrictions affecting small unmanned aircraft operation;

(3) Official sources of weather and effects of weather on small unmanned aircraft performance;

(4) Small unmanned aircraft system loading and performance;

(5) Emergency procedures;

(6) Crew resource management;

(7) Radio communication procedures;

(8) Determining the performance of small unmanned aircraft;

(9) Physiological effects of drugs and alcohol;

(10) Aeronautical decision-making and judgment; and

(11) Airport operations.[157]

2. Skills Requirements

This subsection takes the black-letter private-pilot flight proficiency requirements from 14 C.F.R. § 61.107 and annotates them to produce a set of skills requirements suitable for DROPs.

> (a) *General.* A person who applies for a ~~private pilot~~ ***DROP*** certificate must receive and log ground and flight training from an authorized instructor on the areas of operation of this section that apply to the sUAS category and class rating sought.
>
> (b) *Areas of operation.*
>
> (1) ~~For an airplane category rating with a single-engine class rating~~:
>
> (i) Preflight preparation;
>
> (ii) Preflight procedures;
>
> ~~(iii) Airport and seaplane base operations;~~
>
> (iv) Takeoffs, landings, and ~~go-arounds~~ ***hovering***;
>
> (v) Performance maneuvers:
>
> ***Maintaining line of sight;***
>
> ***Maintaining control link;***

157. NPRM, *supra* note 2, at § 107.73 (Initial and recurrent knowledge tests).

Maintaining attitude control despite sUAS orientation;

Flying from point-to-point;

~~(vi) Ground reference maneuvers;~~

~~(vii) Navigation;~~

~~(viii) Slow flight and stalls;~~

~~(ix) Basic instrument maneuvers;~~

(x) Emergency operations:

Loss of control link;

Battery exhaustion

~~(xi) Night operations, except as provided in §61.110 of this part; and~~

(xii) Postflight procedures.

B. Training and Testing Infrastructure

Responsibility for implementation any licensing program for DROPs requires infrastructure to implement it. A considerable infrastructure already exists for manned aircraft flight training, and the NPRM adopts it for DROP knowledge testing,[158] some parts of which could be adapted relatively easily to accommodate DROP training. Some 500 flight schools exist in the United States accredited by the FAA under Part 141.[159] Many more, almost one at every airport, operate without specific flight school designation and without detailed supervision of their curricular content and teaching methods. Instead, their activities are governed by Part 61[160] and Part 91.[161] Part 61 prescribes the stages in training programs for different levels of pilot certificate, the content of ground instruction[162], knowledge tests, [163] the content of flight training,[164] and – along with the FAA's practical test standards documents[165]—the content of practical test checkride.[166] CFIs have incentives to graduate a certain number of students who pass their knowledge and practical on the first

158. NPRM, *supra* note 2, at 107-110 (explaining how DROP test will be administered).

159. 14 C.F.R. § 141 (2013). See http://av-info.faa.gov/PilotSchool.asp (listing accredited flight schools).

160. 14 C.F.R. § 61 (2013).

161. 14 C.F.R. § 91 (2015).

162. 14 C.F.R. § 61.105(a)-(b) (2013); 14 C.F.R. § 61.107(a)(b) (2013).

163. 14 C.F.R. § 61.35 (a) (2013).

164. 14 C.F.R. § 61.109(c) (2013).

165. Federal Aviation Administration, https://www.faa.gov/training_ testing/testing/ test_standards/ (last visited March 22, 2015) (describing and making available practical test standards).

166. 14 C.F.R. § 61.43(a)-(f) (2013) (specifying content of checkout).

attempt.[167] The knowledge tests themselves are designed by the FAA and its contractors and administered at designated private designated test centers.[168]

Practical test check rides are administered mostly by DPEs,[169] CFIs who have been selected by the FAA to represent the agency in this capacity and who exercise authority on behalf of the FAA administrator when they are giving the test.[170]

One cannot simply assign DROP skills training and testing to this infrastructure, because its components have no experience with drones—and not necessarily any interest in training their operators. A handful of flight schools are adding drone programs,[171] as are several of the established aeronautical universities.[172] Additionally, some universities not specializing in aviation have added DROP programs.[173]

Before one can flesh out the infrastructure for DROP training two crucial personnel decisions must be made and the pipeline needs to fill in response to the decisions. The first is: Who will be the instructors? Existing CFI's and ground instructors? A new category of CFI and ground instructors? Or will DROP training be the responsibility of someone else?

Second, who will be the DROP examiners? Existing DPEs or someone else? It may be tempting simply to say that DROPS must take training—whatever is prescribed—from currently certified CFIs, and that they must pass practical test rides administered by currently designated pilot examiners. There are some advantages to using existing personnel; a part of their training and certification involves mastery of teaching techniques and national security screening. The problem with that approach is that the current stock of CFIs and DPEs have no knowledge or experience with drones, and many of them have no interest in acquiring that knowledge and experience. A CFI with a rotary wing rating is not authorized to give flight instruction in a fixed wing aircraft, and many have no interest in doing so. The markets for rotary- and fixed-wing instruction are largely separate. There's no reason to think that the market for DROP instruction will be any less separate.

The technical aspects of current CFI and DPE expertise, however, map poorly to DROP training, as the evaluation of existing pilot skills standards in section VII.A.2 makes clear.

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167. 14 C.F.R. § 61.197(a)(2)(i) (2013) (CFI renewal based on student success rate).

168. 14 C.F.R. § 61.33 (2013) (describing test administration); Conduct of Airman Knowledge Tests, FAA, http://fsims.faa.gov/PICDetail.aspx?docId =37E322DFC7FF65D68 52571AA00575D58 (last visited Mar. 30, 2015) (describing private test centers).

169. 14 C.F.R. § 61.47 (2013) (describing DPE).

170. 14 C.F.R. § 61.47 (2013) (describing DPE authority).

171. *See, e.g.*, *Aviation*, NORTHWESTERN MICHIGAN UNIVERSITY, https://www.nmc.edu/programs/academic-programs/aviation/index.html (last visited on Mar. 30, 2015).

172. *See, e.g., Daytona Beach Campus*, EMBRY-RIDDLE AERONAUTICAL UNIVERSITY, http://daytonabeach.erau.edu/degrees/bachelor/unmanned-aircraft-systems-science/.

173. *See, e.g., Aviation*, UNIVERSITY OF NORTH DAKOTA, http://aviation.und.edu/Prospective Students/Undergraduate/uasops.aspx.

An obvious alternative is to erect a system of manufacturer-run training. Drone manufacturers such as DJ I would set up their own network of DROP training schools. There is no reason that cannot also train DROPs for other drone models as well; that would be left up to negotiation among vendors in the marketplace. The advantage of this approach is that manufacturers know better than anyone else the characteristics of their flight vehicles and the details of their automatic systems. They likely have their own test pilots who have experience with the vehicles rivaling anyone else's.

Two major disadvantages exist for this approach, however. First, only the larger manufacturers would have the resources to do flight training effectively; yet the market is quite competitive and fragmented among many different designers and vendors. Competition is healthy in any marketplace, and a training requirement that would tend to squeeze out the smaller players is not desirable policy.

Second, even the larger vendors would be unlikely to set up DROP training academies at more than one or two locations. Having to travel halfway across the country and make arrangements for lodging away from home would represent a significant barrier to DROP entry.

Looking to private organizations for DROP skills certification activities is desirable because it opens up more possibilities for building a community of DROPs in which peer group pressure can reinforce safe practices and skill development, and because the private sector has greater flexibility in decision-making, compared with governmental agencies.

A number of models exist for this. One of the most interesting is the Professional Association of Dive Instructors ("PADI"). PADI emerged in 1966 because of a perception by its founders that the existing organizations offering training and certification of scuba divers were poorly organized and not very effective.[174] It has grown into an elaborate organization that offers diver certification at multiple levels.[175] It is difficult for a diver to rent diving gear unless she can show a certificate of completion of at least the basic course. There is almost no governmental involvement; the market enforces the requirements, backed up by the possibility of liability and insurance requirements.

There is no reason that a PADI-like organization cannot be erected for DROPs. Similar to PADI, it would offer memberships, recruit instructors, administer training programs and standards for certifying them, and issue instructor certificates. It would pair certified instructors with divers or would-be divers. It would develop tests that could be administered directly by instructors or online. It would issue certificates of completion of various levels of instruction and testing.

174. *PADI History*, PADI, http://www.padi.com/scuba-diving/about-padi/padi-history/ (last visited on Mar. 30, 2015).

175. *PADI Open Water Diver Course*, PADI, http://www.padi.com/Scuba-Diving/padi-courses/course-catalog/open-water-diver/ (last visited on Mar. 30, 2015).

Other models can be adapted from lifeguard certification—a process in most states administered by the nongovernmental Red Cross and backed up by hiring practices for lifeguards.[176] Also helpful is young hunter, motorboat, snowmobile education and testing requirements in states like Illinois. Under these programs, the requirement for certification is expressed in statute and enforced by the state Department of Natural Resources, but mostly private instructors certified by the DNR conduct the training itself.[177] In Illinois, young hunters may not obtain a hunting license unless the hunter successfully completes a hunter safety course approved by the Department of Natural Resources.[178] The Illinois Department of Natural Resources administers four mandatory safety education courses, in boating, hunting, trapping, and snowmobiling.[179] The hunting course comprises 10 hours of instruction and successful completion of a final exam.[180] Course completion entitles the graduate to a Hunter Education Certificate of Competency.

The boating course is required before a person between the ages of 12 and 18 can operate a motorboat. It comprises 8 hours of instruction. Like the hunting course, it can be completed online. The snowmobile course is similar to the boating course, except that it is required for the age span 12-16.[181]

C. American Association of Drone Instructors

As section 0 and Seeking Law Abiding Drones[182] explain, formal law is only part of the set of rules with which citizens comply. Citizens also conform their conduct to other norms that they have been socialized to respect: for example, taking hats off inside, saying "please," and "thank you," offering to share the cost of a restaurant meal. Professional and industry organizations adopt codes of good practice; some, as section VIII.B explains, providing training, testing, and certification programs.

The most promising infrastructure for training, testing, and certification of microdrone and perhaps for machodrone DROPs as well, would be modeled on PADI, Red Cross lifeguard certification, and loosely on licensing of physicians and attorneys. It would draw upon and strengthen the private center of gravity of manned aircraft pilot licensing, as well.

176. *Lifeguarding*, AMERICAN RED CROSS, http://www.redcross.org/take-a-class/program-highlights/lifeguarding (last visited on Mar. 30, 2015).

177. ILLINOIS DEP'T OF NATURAL RESOURCES, SAFETY EDUCATION (2015) http://www.dnr.illinois.gov/safety/Pages/default.aspx (explaining certification programs for young hunters, archers, snowmobile and boating operators).

178. 520 ILCS 5/3.1-9; 3.2, (providing for certificate of competency by persons completing courses taught by Department personnel or "certified volunteer instructors").

179. *Safety: Safety Education*, ILL. DEP'T OF NATURAL RES., http://www.dnr.illinois.gov/safety/Pages/default.aspx (last visited Mar. 30, 2015).

180. *Safety: Hunter Safety*, ILL. DEP'T OF NATURAL RES., http://www.dnr.illinois.gov/ safety/Pages/HunterSafety.aspx (last visited Mar. 30, 2015).

181. *Safety: Snowmobile* Safety, ILL. DEP'T OF NATURAL RES., http://www.dnr.illinois.gov/safety/Pages/SnowmobileSafety.aspx (last visited Mar. 30, 2015).

182. Cass R. Sunstein, *Social Norms and Social Roles*, 96 COLUM. L. REV. 903, 914 (1996).

Preparing DROPs for safe operation of microdrones would be the responsibility of a private association tentatively known as AADI—American Association of Drone Instructors. AADI would be a private nonprofit membership organization organized under the laws of one or more states. It would have four classes of members: DROP instructors, DROP candidates, qualified drops, and other interested persons.

Its governing body, whether denominated Board of Directors or Board of Trustees, would be controlled by persons selected by the membership, but would also have representation from key stakeholders in the microdrone industry and the aviation community, including representatives of state and local government, manned aircraft pilots, the airlines, and general aviation organizations. It might be chartered as a federal advisory committee to the FAA, although this is not necessary to its success.

AADI would develop detailed curricula for DROP training, follow the NPRM specifications for DROP knowledge, develop skills standards, and would offer training materials in book and online form and practical test standards for DROP skills testing.

Initially, AADI would recruit and qualify a cadre of DROP instructors. At the beginning, CFIs would train DROP instructors, working from its curricula and training materials and test standards rather than from existing part 61 requirements for pilots. As soon as a DROP instructor has been certified as satisfying the

requirements, the responsibility for training DROPs would be shared between certified DROP instructors and CFI's. As soon as a DROP instructor has been certified, he would begin training DROP candidates. No particular critical mass is necessary before training could begin.

AADI would maintain a database of certifications. Once a DROP instructor certifies a DROP candidate, the instructor would submit an online form that automatically would cause an entry to be made in the database. AADI would periodically audit, on an essentially random basis the training and testing activities of its instructors.

AADI also would maintain a database of drone complaints that could be filed by anyone on a standard but simple form that would identify time, place, and basic information such as the risk perceived by the reporting person or entity, and flight profiles such as height above the ground, speed, direction of flight, and proximity to other aircraft or to persons or property on the ground. Both the database of certified DROP instructors and DROPs and the database of complaints would be available to the public through AADI's web site.

Many private associations exist in the United States, and they attract widely varying degrees of attachment from their members. Some—Aircraft Owner and Pilot's Association (AOPA) might be a good example—are prominent advocates of the interests of their members, but do not have much gravitational pull psychologically. Members pay dues to support AOPA's lobbying and educational activities, but membership events do not occupy a prominent part of their lives; nor do they identify strongly with the organization. Others, like many religious organizations, have strong bonds with their members. Still others wax and wane over their lives in the strength of attachment, while others, like American political parties, have some with weak attachment, for whom party membership is just a convenient way to label their political preferences, and others who are passionately involved in political campaigns, party caucuses, primaries and other organizational and candidate selection and platform writing activities.

AADI would pursue a strategy that would place it at the higher end of member bonding. This is necessary for several reasons. First, AADI's status and credibility must be such that it induces DROP candidates to participate in AADI's training and testing activities and to seek AADI certification. Second, members need to care enough about AADI as an umbrella for their professionalism for peer support, and AADI criteria must be credible enough that it is the primary reference point for good operating practices. In other words AADI must be a community, whose members care about each other. Third, suspension or revocation of AADI certification must matter, and loss of AADI membership must have consequences.

AADI would offer coffee mugs, caps, bumper stickers, and pens with the AADI logo. It would sponsor blogs for DROP instructors, certified DROPs, and DROP candidates on its website and be active in social media. It also would sponsor live meetings around the country at which vendors and others could demonstrate new products and provide technical and marketing seminars.

One way to assure these hallmarks of success is effective organization purely in the private sector. PADI and the Red Cross (for its lifeguard certification), for example, do not enjoy any governmental imprimatur. Even though no federal or state rules require SCUBA divers to get PADI certification, they do it anyway. One reason is that diving equipment rental enterprises view PADI certification is an easy way of assuring that the customer is unlikely to have an accident that would result, at least, in the loss of equipment, and might result in litigation and insurance claims.[183]

No governmental imprimatur requires network engineers to have Microsoft or Cisco certification of their skills, but the operation of supply and demand in the labor market gives certificate holders a perceived advantage in hiring and advancement.[184]

Alternatively, AADI could be linked more explicitly to regulatory requirements. The linkage might be similar to that imposed by bar admissions agencies, usually specialized regulatory agencies exercising governmental power under the authority of a state's highest court,[185] and law schools.[186] In most

183. *See* PROFESSIONAL ASSOCIATION OF DIVING INSTRUCTORS, WHY PADI, (2015) http://www.padi.com/scuba-diving/about-padi/why-choose-padi/ (explaining advantages of PADI certification).

184. *See* MICROSOFT, THE ADVANTAGES OF OFFICIAL MICROSOFT AND CISCO CERTIFICATION TRAINING COURSES, (2015) https://social.microsoft.com/Forums/en-US/4d8c5191-8db0-4d7c-accc-99e83e8e0d16/the-advantages-of-official-microsoft-and-cisco-certification-training-courses?forum=CertGeneral.

185. *See, e.g.*, Ill. S. Ct. R. 702 (eff. Jan. 1, 2013) (describing board of bar admissions appointed by state supreme court), http://www.state.il.us/ court/SupremeCourt/ Rules/Art_VII/ artVII.htm.

states, no one may take the bar exam or be admitted to the bar except upon proof of graduation from an accredited law school.[187] The accreditation process for all schools is itself private.

The FAA and state aviation authorities would require the possession of AADI certification to fly microdrone, just as Illinois requires possession of firearms or snowmobile certification, leaving the certification process almost entirely up to private entities.

This degree of governmental involvement, while it may be necessary to reassure the public as to the integrity of the certification process, raises both delegation-doctrine and antitrust issues as when any private association exercises quasi-governmental authority. Delegation-doctrine concerns could be satisfied in either one of two ways, or by a combination of both. First, any governmental penalties for drone operations without AADI certification would be imposed only after a de-novo investigation, notice, and hearing by the governmental authority. The certification by AADI, or lack thereof would operate as a legal presumption in the adjudicatory enforcement proceeding. AADI certification would be prima-facie evidence of qualification; absence of certification would be prima-facie evidence of lack of qualification to operate the microdrone without violating the ban against reckless operation under the CFRs.[188] But the respondent would be legally entitled to rebut the presumption that AADI certification was necessary.

Under the second approach AADI would function and relate to its members as any private association would, free of governmental requirements or restraints, but the FAA would not impose governmental sanctions for violation of AADI rules themselves. Instead, AADI would be constituted as a federal advisory committee, and the FAA would regularly take AADI standards and issue them as proposed FAA rules, followed by notice and comment rulemaking. This is the process statutorily approved for negotiating rulemaking.[189]

Under this approach, delegation-doctrine problems would be eliminated, because private organizations would not be making or enforcing rule via governmental power; the government would. The obvious disadvantage is that the prospect of governmental adoption and codification of AADI rules and processes would devalue the AADI content unless and until it has been formally embraced by the FAA, and that process could take many months or years, depending on the level of controversy.

186. *See*, *e.g.*, Ill. S. Ct. R. 703(b) (eff. July 1, 1992) (requiring graduation from ABA-approved lawschool), http://www.state.il.us/court/SupremeCourt/Rules/Art_VII/artVII.htm.

187. *Id*.

188. 14 CFR § 91.13 (2014) (prohibiting careless and reckless operation).

189. 5 U.S.C. § 553 (2011); Henry H. Perritt, Jr., *Negotiated Rulemaking Before Federal Agencies: Evaluation of Recommendations by the Administrative Conference of the United States*, 74 GEO. L.J. 1625, 1642-1647 (1986).

The antitrust strictures are more easily accommodated. In a series of cases, the Supreme Court's decision in *Radiant Burner*[190] has been fleshed out in the context of many controversies over private standard-setting organizations. The antitrust concern is that dominant firms in an industry would seize a standard-setting organization and use its standards to exclude competitors.[191]

To prevent this, the *Radiant Burner* case law,[192] and several Justice Department safe-harbor guidelines[193] require the following: (1) Open membership; (2) Transparency of standards development processes, and (3) Justification of the content of standards or rules adopted by the organization[194]

The end result is not unlike that imposed by the Administrative Procedure Act on federal agencies; rulemaking must be rational, open for public input, explicitly justified in terms of logic and evidence.[195] Adjudicatory procedures must offer the basic ingredients of a procedural due process.[196]

To be sure, organizing and maintaining a private association, especially one intended significantly to affect member behavior, is challenging.[197] But AADI's organizers, mindful of the literature on organization viability, would embrace a strategy likely to achieve success.

As section IV explains the government, through the FAA, could reinforce the viability of an organization like AADI, while avoiding delegation and antitrust problems by requiring that DROPs be a member of *some* organization and satisfy its certification requirements. It would define the characteristics of the certifying organization without mandating membership in any particular one. This would allow the market to adapt and allow for new association entrants to innovate and improve on the services offered by existing organizations, much as PADI emerged when its founders believed they could do better than existing diver certification bodies.

190. *Radiant Burners, Inc. v. Peoples Gas Co*., 364 U.S. 656 (1961).

191. *Id.* at 658.

192. *See American Society of Mechanical Engineers, Inc. v. Hydrolevel Corp*., 456 U.S. 556 (1982); *Allied Tube & Conduct Corp. v. Indian Head, Inc.*, 486 U.S. 492, 500 (1988).

193. *See* Hill B. Wellford, *Antitrust Issues in Standard Setting*, DEP'T. OF JUSTICE, http://www.justice.gov/atr/public/speeches/222236.htm (March 29, 2007) (reviewing DOJ policy on standards setting organizations).

194. *See* Henry H. Perritt, Jr., *Towards a Hybrid Regulatory Scheme for the Internet*, 2001 U. CHI. LEGAL F. 215, 287 (explaining criteria for standard setting resulting from Radiant Burners and its progeny).

195. *See* 5 U.S.C. § 553; *Cape Code Hospital v. Sibelius*, 630 F.3d 203, 211-212 (D.C. Cir. 2011) (vacating rule on Medicare reimbursement of hospitals because agency failed to give sufficient consideration to comments).

196. *See* 5 U.S.C. § 556-557.

197. *See* Mancur Olson, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS (1971) (explaining social and economic dynamics that tend to undercut effective functioning of large groups).

Although the financial aspects of AADI are beyond the scope of this article, its financial viability would be assured by combination of membership fees, testing fees, certification fees, and charitable donations from interested parties**.**

The AADI concept is useful regardless of shifting interpretations of the boundary between federal, state, and local control, depending on how preemption and commerce clause doctrines evolve in light of the fact that most microdrone flight has minimal effect on interstate commerce and that most of the safety and privacy concerns are strictly local.

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