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DRONES, AIRSPACE, AND THE SHARING ECONOMY

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Abstract

Commercial drone industry advocates have asserted for years that drone services will be limited in the United States so long as private landowners are legally entitled to exclude drones from the low airspace above their land. Sadly, the industry's efforts to weaken airspace rights laws to make way for commercial drones have stalled the development of private airspace sharing systems—an alternative approach to drone routing that could finally unleash commercial drone services across the country. This paper describes how policies that embrace rather than ignore landowners' property interests in the low airspace above their land could accelerate the deployment of commercial drone technologies. By enacting new laws that affirm and more clearly define landowners' airspace rights, legislators could enable the emergence of private airspace sharing platforms capable of opening up commercial drone activity in much of the country's low airspace. Business models built on such platforms and legal frameworks would also promote greater public acceptance of drone overflights and more efficient use of the nation's valuable airspace resources.

JEL codes: R4, R51, R52, K2, K23, K39, H1

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Troy A. Rule

Introduction

For years, futurists have predicted that legions of commercial unmanned aircraft systems (UASs) or "drones" would soon be traversing the nation's skies delivering pizzas, transporting retail goods, and snapping aerial real estate photos.[1] Recent technological advancements have made such visions plausible for the first time, and some of the world's largest companies are actively working to make them a reality. However, one major obstacle is slowing this progress: existing property laws that entitle landowners to exclude objects from the immediate reaches of airspace directly above their land. To date, courts and legislators have been reluctant to ignore or disregard long-standing property laws to open up low airspace for drones. Consequently, despite several years of efforts to change or circumvent these laws, the nation's commercial drone services industry remains largely grounded.[2]

Although extinguishing landowners' rights to exclude drones from their low airspace would surely simplify the nationwide rollout of commercial drone technologies, it would also be possible to promote such a rollout by strengthening and clarifying those rights instead. In fact, the growing competition for low airspace uses in the drone era arguably warrants such a policy

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[1] *See, e.g.*, Agence France-Presse, *FAA: Number of US Drones Will Triple by 2020*, INDUSTRYWEEK.COM (Mar. 25, 2016), https://www.industryweek.com/technology-and-iiot/article/21972014/faa-number-of-us-drones-will-triple-by-2020 (predicting in 2016 that 2.7 million commercial drones would be operating in the United States by 2020).

[2] *See* Fed. Aviation Admin., *UAS by the Numbers*, https://www.faa.gov/uas/resources/by_the_numbers/ (last visited Oct. 28, 2021) (showing only 340,247 registered commercial drones in the United States as of October 2021). See also Faith Greenwood, *Assessing the Impact of Drones in the Global COVID-19 Response*, BROOKINGS.EDU (July 20, 2021), https://www.brookings.edu/techstream/assessing-the-impact-of-drones-in-the-global-covid-response/ (observing that the drone industry had hoped that "a historically drone-skeptical public might be won over by [drone] technology once and for all" as drones provided services during the COVID-19 pandemic, but that drones ultimately had little impact, "undermining efforts [to] demonstrate the genuinely helpful ways drones can be deployed and build public support for the technology").

response.[3] New legislation affirming and clarifying landowners' airspace rights would not only be consistent with existing laws; it would also create fertile ground for the emergence of private airspace-sharing platforms for drones. Such systems would foster more widespread public acceptance of commercial drone activities and harness market forces to promote more efficient and equitable low airspace governance in the drone era.

This paper argues that strengthening and clarifying landowners' airspace rights would facilitate the development of airspace-sharing platforms capable of accelerating the deployment of commercial drone technologies in the United States. In doing so, this paper directly challenges commercial drone industry advocates' position that extinguishing or ignoring landowners' airspace rights is the only way to unleash widespread commercial drone operations across the country. Part I of this paper outlines how technological advancements over the past decade have sparked unprecedented debates over the scope of landowners' property interests in the low airspace above their land, and how major companies have sought to leverage their influence to diminish or eliminate those rights. Part II describes policy changes capable of aiding the development of digital platforms designed to coordinate transactions among landowners and businesses to open up airspace across the country for commercial drone activities. Under this property-based approach, landowners would license temporary access to their airspace to drone users through systems that promoted greater public acceptance of drone overflights and more efficient utilization of the nation's low airspace.

I. Low Airspace and Commercial Drones

UAS or "drone" technologies have the potential to transform delivery services in the United States in ways that would benefit millions of Americans. Small civilian drones offer numerous

[3] *See generally*, Troy A. Rule, *Airspace in an Age of Drones*, 95 B.U. L. REV. 155, 189–94 (2015).

advantages over ground-based vehicles and manned aircraft in the local delivery of goods. Drones can fly autonomously without a pilot or driver on board, enabling them to transport small items using considerably less energy and labor.[4] Autonomous drones also require no physical road infrastructure and can fly routes with remarkable precision, enabling them to quickly and easily access areas that would be costly or time-consuming to reach through any other means. Because of their many advantages, civilian drones are already beginning to assist in a diverse range of public and commercial activities, from firefighting to pipeline inspections.[5] However, drone-assisted goods delivery systems have the potential to achieve much more by improving the speed and cost-effectiveness of deliveries while simultaneously reducing road congestion and greenhouse gas emissions.[6]

Recognizing the tremendous potential of autonomous drones as deliverers of goods, some of the world's largest companies have been actively developing drone-assisted delivery systems for several years. Among them are UPS Flight Forward, Amazon's Prime Air, and Alphabet's Wing Aviation—all of which now hold Federal Aviation Administration (FAA)–issued Standard Part 135 air carrier certificates for drone-assisted delivery operations.[7] The FAA has also adopted

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[4] *See, e.g.*, Wen Chyuan Chiang et al., *Impact of Drone Delivery on Sustainability and Cost: Realizing the UAV Potential through Vehicle Routing Optimization*, 242 APPLIED ENERGY 1164 (2019) (finding that "routing and delivering packages with UAVs would save energy" and be "cost effective and environmentally friendly").

[5] *See* Timothy R. Ravich, *Grounding Innovation: How Ex-Ante Prohibitions and Ex-Post Allowances Impede Commercial Drone Use*, 2018 COLUM. BUS. L. REV. 495, 498 (noting that the drone industry encompasses "precision agriculture, aerial photography and journalism, urban planning, real estate, insurance, pipeline and railroad monitoring, construction, emergency management, power line inspection, educational and academic uses, entertainment, and—perhaps most rousing—logistics and telecommunications").

[6] *See, e.g.*, Jean-Philippe Aurambout, Konstantinos Gkoumas, & Biagio Ciuffo, *Last Mile Delivery by Drones: An Estimation of Viable Market Potential and Access to Citizens across European Cities*, 11 EURO. TRANSPORT RESEARCH REV. 30 at 2 (2019) (describing potential economic and social cost advantages of using drones for last-mile delivery services, including reduced labor costs, delay costs, and congestion costs).

[7] *See* PACKAGE DELIVERY BY DRONE (PART 135), FAA.GOV, https://www.faa.gov/uas/advanced_operations/package_delivery_drone/ (last visited Oct. 25, 2021); Annie Palmer, *Amazon Wins FAA Approval for Prime Air Drone Delivery Fleet*, CNBC.COM (Aug. 31, 2020), https://www.cnbc.com/2020/08/31/amazon-prime-now-drone-delivery-fleet-gets-faa-approval.html.

new rules in recent years designed to aid the commercial drone industry's growth, including new drone remote identification system regulations and rules to govern drone flights over people.[8] The COVID-19 pandemic has further accelerated commercial drone services growth by spurring increased demand for contactless goods deliveries.[9] For these and other reasons, the global market for drone delivery services alone is projected to expand from $1.57 billion in 2020 to $5.32 billion by 2025.[10]

Despite their tremendous potential, commercial drone companies face significant legal obstacles within the United States that have heretofore prevented them from broadly expanding their operations throughout the country. In addition to FAA regulations designed to ensure the safety of manned aviation and state statutes restricting other aspects of drone use, commercial drone operators must contend with private landowners who claim rights to exclude drones from the low airspace directly above their land.[11] The potential transaction costs associated with purchasing voluntary easements or licenses from each landowner below a drone's flight path have long seemed insurmountable.[12] As the following sections describe, commercial drone advocates have thus campaigned aggressively in recent years for policies that would circumvent or disregard property laws and give drone operators free access to landowners' private airspace.

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[8] FAA, REMOTE IDENTIFICATION OF UNMANNED AIRCRAFT, FINAL RULE, 86 Fed. Reg. 4390 (Jan. 15, 2021); FAA, OPERATION OF SMALL UNMANNED AIRCRAFT SYSTEMS OVER PEOPLE, 86 Fed. Reg. 4314 (Jan. 15, 2021).

[9] *See* Aaron Pressman, *Drone Industry Flies Higher as COVID-19 Fuels Demand for Remote Services*, FORTUNE.COM (July 13, 2020), https://fortune.com/2020/07/13/coronavirus-drones-dji-wing-flytrex-covid-19-pandemic/.

[10] *See Delivery Drone Services Global Market Report 2021: COVID-19 Implications and Growth*, REPORTLINKER.COM (Sept. 2021), https://www.reportlinker.com/p06144622/Delivery-Drone-Services-Global-Market-Report-COVID-19-Implications-and-Growth.html?utm_source=GNW.

[11] For a detailed overview of federal and state drone laws and regulations through 2017, *see generally*, Hilary B. Farber, *Keep Out! The Efficacy of Trespass, Nuisance and Privacy Torts as Applied to Drones*, 33 GA. ST. U. L. REV. 359, 367–79 (2017).

[12] *See, e.g.*, Tyler Watson, *Note: Maximizing the Value of America's Newest Resource, Low Altitude Airspace: An Economic Analysis of Aerial Trespass and Drones*, 95 IND. L.J. 1399, 1442–43 (2020) (calling the transaction costs associated with securing the easements or licenses needed for drone delivery routes "prohibitively high").

A. History of Private Airspace Rights

Landowners' airspace exclusion rights have emerged as a significant impediment to the deployment of commercial drone technologies across the United States in recent years. Most small commercial drones are designed to operate within 500 feet of the ground in a layer of space known as non-navigable airspace, which has historically been below the minimum allowable altitude for manned aircraft.[13] The US Supreme Court ruled in *US v. Causby* more than 75 years ago that landowners do not hold indefinite airspace rights "up to the sky" above their land—as a literal reading of the English common law's centuries-old *ad coelum* rule purported to provide—and that all space above the navigable airspace line is instead a communally shared "public highway" for air travel.[14] This rule, established relatively soon after the advent of manned aviation, spared airlines from having to negotiate voluntary avigation easements with hundreds or thousands of underlying landowners to legally complete cross-country flights—a requirement with such prohibitively high transaction costs that it would have quickly grounded the nation's budding aviation industry.[15] The *Causby* court made clear, however, that landowners do hold property interests in the "immediate reaches" of space directly above their parcels.[16] Specifically, landowners own "at least as much of the space above the ground as [they] can occupy or use in connection with the land."[17] As subsequent courts continue to affirm today, intrusions into that low airspace thus constitute a trespass no different from intrusions onto land.[18]

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[13] *See, e.g.*, Claassen v. City and County of Denver, 30 P.3d 710, 712 (2000) (stating that surface owners hold property interests in the airspace above their land that is "below navigable limits," which are generally defined as 500 feet above the surface in noncongested populated areas) (citing 14 C.F.R. § 91.119(b), (c) (2000)); *see also* Farber, *supra* note 11 at 384 (explaining that civilian drones "generally operate between 50 and 500 feet above ground").

[14] *See generally*, 328 U.S. 256 (1946).

[15] *See* Stuart Banner, WHO OWNS THE SKY? THE STRUGGLE TO CONTROL AIRSPACE FROM THE WRIGHT BROTHERS ON, 291–93 (2008) (describing the potential transaction cost problems associated with manned aviation in navigable airspace).

[16] Id. at 260–61.

[17] Id. at 260–65.

[18] *See, e.g.*, Long Lake Township v. Maxon, 2021 WL 1047366, *7 (Mich. App. 2021) (holding that "landowners are still entitled to ownership of some airspace above their properties, such that intrusions into that airspace will constitute a trespass no different from an intrusion upon the land itself").

Although the *Causby* court's "immediate reaches" language furnished some new guidance regarding the scope of landowners' rights in the airspace immediately above their parcels, it did not specify how high that area of privately owned space extends above private land. FAA regulations have likewise prohibited manned aircraft from dipping to within 500 feet of the ground in most settings, so courts in the decades following *Causby* have had few opportunities to fill this gap.

B. Recent Attempts to Extinguish Landowners' Airspace Exclusion Rights

As commercial drone technologies have increased the value of low-altitude airspace in recent years, there has been unprecedented pressure to redefine the scope of landowners' rights in this space.[19] Most notably, commercial drone industry stakeholders—recognizing the sizable hurdles private airspace rights could create for their operations—have advocated for a federal drone regulatory structure that would largely disregard landowners' long-held airspace rights.[20] The sweeping federal policy actions they have sought would govern low airspace access through FAA authorizations, effectively eliminating landowners' rights to exclude drones from the low airspace directly above their land.[21]

It is hardly surprising that the FAA and major drone industry stakeholders have lobbied for legislative and regulatory changes that would eliminate landowners' drone exclusion rights in

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[19] For a detailed discussion of how the recent increase in interest in clarifying airspace rights is consistent with Demsetzian property theory, *see generally*, Rule, *Airspace in an Age of Drones*, *supra* note 3 at 189–94.

[20] *See, e.g.*, *Hearing on Drones: The Next Generation of Commerce? Before the Comm. on Oversight & Gov't Reform*, 114TH CONG. 6 (2015), https://oversight.house.gov/wp-content/uploads/2015/06/Amazon-Misener-HOGR-Testimony-Pkg-6-17-15-rev.pdf [https://perma.cc/X3Y4-HYLB] (testimony of Paul Misener, vice president for global public policy at Amazon.com, arguing that states and municipal governments should not be allowed to restrict the flights of FAA-authorized drones "given the interstate nature of commercial [drone] operations").

[21] *See, e.g.*, Troy A. Rule, *Drone Zoning*, 95 N.C. L. REV. 133, 185 (2016) (describing Amazon Prime Air's proposed federal airspace zoning model that would have effectively eliminated landowners' authority to exclude drone overflights).

low airspace. Many of the large companies poised to benefit the most from such changes have business models that have long relied heavily on free open-access resources and infrastructures to operate their businesses. For instance, Amazon makes heavy use of publicly funded roads, airports, and bridges to deliver its packages, yet the company avoided paying federal income taxes for several years.[22] Alphabet (formerly Google) has similarly built its empire by leveraging open-access resources, using the internet's vast infrastructure to generate massive profits through technologies that lead consumers to news and information sources created and funded by others.[23] As major market disruptors, these companies have likewise often shown propensities to apply a "do first, ask forgiveness later" approach when needed to advance their bold business ventures.[24] These same companies are also highly experienced at leveraging their financial and political weight to influence policy decisions affecting their business plans.[25] The FAA has proven to be a willing partner in the effort to reclassify very low airspace and thereby expand FAA jurisdiction and increase the agency's size and relevance—changes that federal agencies characteristically tend to favor.[26]

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[22] *See* Jeremy Mohler, LIKE MANY CORPORATIONS, AMAZON IS SUCCESSFUL BECAUSE OF GOVERNMENT, NOT DESPITE IT, MEDIUM.COM (Mar. 23, 2018), https://medium.com/in-the-public-interest/like-many-corporations-amazon-is-successful-because-of-government-not-despite-it-6b92fabab4b6.

[23] *See* Guardian Staff, *Why Google and Facebook Are Being Asked to Pay for the News They Use*, THE GUARDIAN (Sept. 4, 2020), https://www.theguardian.com/technology/2020/sep/05/why-google-and-facebook-are-being-asked-to-pay-for-the-news-they-use-explainer (noting that "users would find Google or Facebook far less helpful if no news appeared on their feeds or in their search results" and describing the Australian government's proposal to require Google and Facebook to pay publishers to license content for their news tabs).

[24] Erik Sherman, *Google Struggles with Its "Do First, Ask Forgiveness Later" Strategy*, CBSNEWS.COM (Mar. 12, 2010), https://www.cbsnews.com/news/google-struggles-with-its-do-first-ask-forgiveness-later-strategy/.

[25] *See, e.g.*, Ryan Tracy, Chad Day, & Anthony DeBarros, *Facebook and Amazon Boosted Lobbying Spending in 2020*, THE WALL ST. J. (Jan. 24, 2021), https://www.wsj.com/articles/facebook-and-amazon-boosted-lobbying-spending-in-2020-11611500400 (reporting that Amazon spent roughly $18 million on federal lobbying in 2020, which was second only to Facebook).

[26] *See, e.g.*, Jonathan Turley, *Pax Militaris: The Feres Doctrine and the Retention of Sovereign Immunity in the Military System of Governance*, 71 GEO. WASH. L. REV. 1, 39 (2003) (noting that federal agencies have a "common inclination" for "bureaucratic expansion").

The drone industry's campaign to weaken private airspace access rights has evolved significantly over the past decade. After years of controversial lobbying for broad federal or state actions that would directly undercut landowners' rights to exclude drones, commercial drone advocates have recently embraced a more subtle approach of slowly chipping away those rights one FAA-approved pilot program at a time. The following paragraphs briefly describe how the commercial drone industry's campaign to secure access to the nation's low airspace has progressed in recent years from one that boldly challenged landowner airspace rights into one that is gradually eroding those rights.

1. Calls for Federal Preemption of State Property Laws

One of the commercial drone industry's chief strategies for diminishing private airspace exclusion rights has been to argue under federal preemption theories that FAA-authorized drone operators are immune from trespass liability. Because Congress has yet to enact legislation expressly preempting local property laws related to drones and low airspace, drone advocates have primarily based these arguments on a pair of implied preemption theories. They argue under a "conflict preemption" theory that state property laws allowing landowners to exclude drones from the low airspace above their parcels directly conflict with FAA drone regulations.[27] Alternatively, they argue based on a "field preemption" theory that Congress has already fully occupied the "field" of drone industry regulation such that there is no room for state property laws to recognize private airspace rights that could affect that industry.[28] Among other things, they and the FAA

[27] *See, e.g.*, All. for Drone Innovation et al., *Comment Letter on Proposed Uniform Tort Law Relating to Drones Act* 1 (July 5, 2018), https://www.uniformlaws.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=6ec36eed-5f99-8940-abf1-691f8eddeb03&forceDialog=0 [https://perma.cc/56YC-5SNR] (arguing that state laws giving landowners' rights to exclude drones from above their land "stand in direct conflict with federal regulation of air navigation, and thus are preempted by federal law" and that "Congress has occupied the field with regard to air navigation"). *See also* Rule, *Drone Zoning*, *supra* note 21 at 154–56.

[28] *See* All. for Drone Innovation et al., *Comment Letter on Proposed Uniform Tort Law Relating to Drones Act, supra* note 27 at 1. *See also* Rule, *Drone Zoning*, *supra* note 21 at 148–50.

have anchored these arguments on the National Transportation Safety Board's (NTSB's) interpretation of the statutory definitions of "aircraft," which the board ruled in 2014 includes "any aircraft, manned or unmanned, large or small."[29] To be clear, when hovering above 500 feet or near airports, drone operations unquestionably do fall within the FAA's regulatory jurisdiction since they are potential hazards to manned civil aviation activities. However, the FAA has tried to suggest that its jurisdiction over drone operations extends much farther—all the way down to the ground—and exclusively empowers the agency to award access rights in low airspace, even for activities that pose no threat to manned aviation activities.[30] Ignorance of this critical distinction between uses of low airspace that threaten manned aviation safety and uses that do not lies at the heart of the FAA's flawed view of its own drone regulatory jurisdiction. Without this distinction, as the NTSB noted, even a "paper aircraft, or a toy balsa wood glider, could subject the 'operator' to" an FAA enforcement action.[31]

To date, the drone industry's preemption-based arguments for erasing landowners' airspace exclusion rights have done relatively little to open up low airspace for drones. Instead, such implied federal preemption arguments have mostly encountered resistance in US courts. For example, in 2020, a US District Court refused to allow preemption of Texas state restrictions on drone flying below 400 feet, declaring that "federal law has not completely preempted the field regarding UAVs [unmanned aerial vehicles] flying over certain buildings and structures."[32] The same court similarly rejected conflict preemption-based arguments against those restrictions.[33]

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[29] Huerta v. Pirker, No. EA-5730, 2014 WL 8095629, at *2, *5 (N.T.S.B. Nov. 17, 2014) (decisional order).

[30] *See* Darlene Ricker, *Taking Flight—Navigating Drone Laws Has Become a Growing and Lucrative Legal Niche*, 103-JUL A.B.A. J. 56 (2017) (quoting a lawyer's statement that "drone attorneys want the FAA to have jurisdiction all the way down to a blade of grass. . . . Otherwise, it will be a regulatory nightmare").

[31] Huerta v. Pirker, *supra* note 29 at *8.

[32] *See* Nat'l Press Photographers Assoc. v. McCraw, 504 F. Supp.3d 568 (2020) (citing City of El Cenizo, Texas v. Texas, 890 F.3d 164, 176 (5th Cir. 2018)).

[33] *See* Nat'l Press Photographers Assoc., *supra* note 32 at 591.

2. Attempts to Weaken Airspace Rights through State Legislation

Drone industry advocates have also tried to leverage states' legislative powers to gain free access to landowners' low airspace in recent years. Chief among these efforts was the industry's collaboration with the Uniform Law Commission (ULC) to produce model aerial trespass legislation. In 2017, the ULC formed a drafting committee to produce model state legislation to govern drone trespass issues in low airspace.[34] Under early drafts of this model act, unauthorized intrusions of drones into airspace less than 200 feet above privately held parcels would have triggered actionable trespass claims.[35] However, drone industry advocates expressed dissatisfaction with that approach and ultimately convinced the ULC drafting committee to replace it with provisions that would have instead created a nuisance-like balancing test for determining when aerial trespass occurs.[36] This alternative approach would have required courts to balance a lengthy list of factors to make unpredictable case-by-case determinations on whether particular drones' activities over private land constituted an actionable trespass.[37]

Despite years of effort, drone industry advocates' push for new state legislation to open up low airspace for drones ultimately lost steam. The ULC's final draft model act—the "Tort Law Relating to Drones Act"—prompted strong disapproval from the American Bar Association's Real Estate Section, which adopted a formal resolution criticizing the drafting committee's

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[34] *See* Uniform L. Comm'n, *ULC Project List* 6 (Sept. 1, 2017), https://cdn.ymaws.com/www.nabenet.org/resource/resmgr/gr/ULC_Current_Projects_Sept_20.pdf (describing approval of the "Drafting Committee on Tort Law Relating to Drones Act" for the purpose of drafting a "uniform act or model law addressing tort liability and defenses associated with the unique use of aerial drones").

[35] *See* Ronnie R. Gipson, *The Rise of Drones and the Erosion of Privacy and Trespass Laws*, 33 AIR & SPACE LAWYER (2020), https://www.americanbar.org/content/dam/aba/publications/air_space_lawyer/fall2020/asl_v033n03_fall2020_gipson.pdf.

[36] *See* id. (noting that the removal of provisions providing for "per se injury tied to the 200-foot shelf" was intended to "provide greater operational flexibility for drone operators").

[37] *See generally*, Nat'l Conf. of Comm'rs on Uniform State Laws, DRAFT TORT LAW RELATING TO DRONES ACT (2018), https://www.uniformlaws.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=acc3dee9-7ab6-24e3-ee55-ad3e09a82c6a (last visited Nov. 17, 2021).

approach and advocating instead for one based on existing property laws.[38] As of early 2022, despite numerous meetings and negotiations involving dozens of stakeholders, the ULC drafting committee's attempts to build consensus around a model act had been on hold for more than two years.[39]

3. Eroding Airspace Rights through FAA-Authorized "Pilot" Programs

Having found minimal success with its overt campaigns to preempt or rewrite property laws to open up low airspace for drones, drone industry advocates appear to have recently adopted a more subtle approach. Rather than continuing to seek a direct knockout punch, industry stakeholders have increasingly focused on quietly eroding landowners' airspace exclusion rights—one isolated pilot program at a time. Over the past few years, the FAA has authorized a handful of companies to engage in limited commercial drone activities.[40] A growing number of these FAA pilot program approvals authorize low drone overflights over private property without requiring permission from underlying landowners.[41] These localized authorizations generally have been narrow in scope and thus flown under the radar of property rights advocates, but their cumulative

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[38] *See* Amer. Bar Assoc. Res. 111, Part III (Feb. 17, 2020), https://www.americanbar.org/content/dam/aba/directories/policy/midyear-2020/2020-midyear-111.pdf (last visited Nov. 17, 2021) ("The most effective manner to protect and address landowner and legal occupant interests and concerns related to UAS usage is to use and apply the existing common law trespass principles to protect private property rights with respect this new and emerging UAS technology").

[39] The ULC's Drafting Committee "suspended its work in January 2020 reportedly in part due to disagreement over property rights in airspace." U.S. Gov. Accountability Office, UNMANNED AIRCRAFT SYSTEMS: CURRENT JURISDICTIONAL, PROPERTY, AND PRIVACY LEGAL ISSUES REGARDING THE COMMERCIAL AND RECREATIONAL USE OF DRONES, APPENDICES I–VI at 22 (Sept. 2020), https://www.gao.gov/assets/B330570_Appendices.pdf.

[40] *See* PACKAGE DELIVERY BY DRONE (PART 135), *supra* note 7 (describing the FAA's issuance of Part 135 air carrier certifications to Wing Aviation LLC and UPS Flight Forward, Inc., for limited drone delivery operations in two US communities and noting that the agency is "currently working on six additional Part 135 air carrier certificate applications"). *See also* Alan Boyle, *FAA Issues Safety Rules That Could Smooth the Way for Amazon Drone Deliveries*, GEEKWIRE.COM (Dec. 28, 2020), https://www.geekwire.com/2020/faa-issues-safety-rules-smooth-way-amazon-drone-deliveries/ (reporting that "Amazon's Prime Air division won the FAA's designation as an air carrier in August [2020], following up on similar moves involving UPS and Wing").

[41] *See* Boyle, *supra* note 40 (noting that "UPS is already collaborating with the CVS pharmacy chain on a pilot program to deliver drugs to a Florida retirement community, while Wing has been making home deliveries on a trial basis for months").

effect pose a major threat to landowner airspace exclusion rights. Whether this latest strategy succeeds will in part depend on how quickly and aggressively landowners take notice and begin challenging it. In the meantime, commercial drone industry growth under this strategy is likely to be gradual at best.

C. Landowners' Airspace Rights Still Standing

Despite the multifaceted opposition they have faced over the past decade, landowners' property interests in the low airspace above their parcels remain intact today. Tactics aimed at weakening landowners' rights have generated uncertainty for some but have ultimately failed to dislodge long-standing property laws governing this space. Courts continue to affirm that landowners are legally entitled to exclude unwanted objects from some amount of space above their parcels.

Although drone industry's advocates' "say it enough and they'll believe it" approach to landowner airspace rights has generated confusion among some stakeholders, US courts thus far continue to remain mostly unfazed by this rhetoric.[42] Language in a 2021 US Supreme Court majority opinion is among the most recent examples of courts' clear recognition that landowners hold exclusion rights in the low airspace above their parcels. In *Cedar Point Nursery v. Hassid*, the Court held that a California regulation giving labor organizations rights to regularly access an agricultural employer's land to solicit union support affected a per se physical taking of an easement.[43] Even though *Cedar Point Nursery* involved repeated intrusions onto surface land,

[42] The increased likelihood that people will believe falsehoods if they hear them repeatedly is known as the illusory truth effect. *See* Mary Anne Franks & Ari Ezra Waldman, *Sex, Lies and Videotape: Deep Fakes and Free Speech Delusions*, 78 MD. L. REV. 892, 895 (2019) (explaining that "repeated exposure to false information, even when presented for the purposes of correction, increases the likelihood that the false information will be remembered as true") (citing Lisa K. Fazio et al., *Knowledge Does Not Protect against Illusory Truth*, 144 J. EXPERIMENTAL PSYCHOL.: GEN. 993, 993–1002 (2015)).

[43] *See* 141 S.Ct. 2063, 2072 (2021) (holding that the regulation at issue "appropriates a right to invade the growers' property and therefore constitutes a per se physical taking," because it "appropriates for the enjoyment of third parties the owners' right to exclude").

the Court's majority opinion made multiple detailed references to *Causby* and to landowners' rights to exclude objects from the airspace immediately above their parcels. Among other things, the Court declared:

> Given the central importance to property ownership of the right to exclude, it comes as little surprise that the Court has long treated government-authorized physical invasions as takings requiring just compensation. . . . In *United States v. Causby* we held that the invasion of private property by overflights effected a taking. The government frequently flew military aircraft low over the Causby farm, grazing the treetops and terrorizing the poultry. The Court observed that ownership of the land extended to airspace that low, and that "invasions of it are in the same category as invasions of the surface." Because the damages suffered by the Causbys "were the product of a direct invasion of [their] domain," we held that "a servitude has been imposed upon the land." *See also* Portsmouth Harbor Land & Hotel Co. v. United States, 260 U.S. 327, 330 . . . (1922) (government assertion of a right to fire coastal defense guns across private property would constitute a taking).[44]

The Court later added:

> In . . . *Causby* . . . we followed our traditional rule: because the government appropriated a right to invade, compensation was due. . . . We cannot agree that the right to exclude is an empty formality, subject to modification at the government's pleasure. On the contrary, it is a "fundamental element of the property right" that cannot be balanced away. Our cases establish that appropriations of a right to invade are per se physical takings, not use restrictions subject to *Penn Central*: "When [government] planes use private airspace to approach a government airport, [the government] is required to pay for that share no matter how small."[45]

These excerpts from a recently issued US Supreme Court opinion, taken together with the drone industry's recent failed efforts to weaken landowner airspace rights through the ULC and state legislatures, are additional evidence that these rights remain strong and certain in the United States. Contrary to what drone industry advocates and FAA officials continue to wishfully claim, landowners are legally entitled to exclude unwanted drones from the low airspace above their land. As more pointed language in a 2021 Michigan state court opinion noted:

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[44] Id. at 2073 (internal citations omitted).

[45] Id. at 2076–78 (internal citations omitted).

> Landowners are still entitled to ownership of some airspace above their properties, such that intrusions into that airspace will constitute a trespass no different from an intrusion upon the land itself. . . . Drones fly below what is usually considered public or navigable airspace. Consequently, flying them at legal altitudes over another person's property without permission or a warrant would reasonably be expected to constitute a trespass.[46]

The inconvenient reality of these exclusion rights continues to weigh down a promising commercial drone delivery industry that is eager to get off the ground.[47]

D. Weak Support for Transferring Airspace Rights to Drone Operators

Tepid support from the general public is one other factor that has hampered the commercial drone industry's campaign to weaken landowners' airspace rights. Americans' enthusiasm for policy changes that would give major corporations such as Amazon free access to their private airspace remains weak at best.[48] According to a peer-reviewed 2019 study, small drone operations were "not well accepted" among a sizable group of American survey respondents "except for public safety and scientific research applications," and "commercial and hobby uses" of drones were decisively "not supported" among those responding to the survey.[49]

Fear that civilian drone activities could undermine landowners' privacy is the primary driver of the rise in drone use restrictions across the country in recent years.[50] For good reason, most

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[46] Long Lake Township v. Maxon, *supra* note 18 at 7 (internal citations omitted). The *Long Lake Township* court did not officially rule on whether a drone overflight constitutes a per se trespass, because that specific question was not before the court.

[47] *See* Brian M. Miller, *Drone Delivery and the Takings Clause*, 6 TEX. A&M J. PROP. L. 139, 168 (2020) (concluding that "moving forward, Amazon will have a decision to make: buy easements from all property owners underneath its desired drone corridors, or lobby the government to declare a drone easement through eminent domain power" and "compensate every affected landowner").

[48] *See* Carey L. Biron, *ANALYSIS—Sky's the Limit: Rise of Delivery Drones Has Cities Asking Who Owns Airspace*, THOMPSON REUTERS FOUNDATION (June 17, 2019), https://news.trust.org/item/20190617084209-8df4r (calling the public's perceptions about drone trespass a "looming problem" for the commercial drone industry and citing one drone program leader's declared view that "without public buy-in, new drone programs 'won't be operational'").

[49] Burchan Aydin, *Public Acceptance of Drones: Knowledge, Attitudes, and Practice*, 59 TECH. IN SOC, 101180 (2019).

[50] *See* id. (interpreting survey results to indicate that the "public sees the drones as a risky technology that directly interferes with their privacy"). *See also* Farber, *supra* note 11 at 377 (stating that "the catalyst for the precipitous rise in drone legislation is privacy" and that "lawmakers are largely concerned with the potential threat to personal privacy presented by the proliferation of these aerial observers").

landowners have long believed that they are legally entitled to keep unwanted objects from hovering just above their land.[51] Consistent with this understanding, many landowners install walls, hedges, and other improvements with the expectation that those barriers will create and preserve privacy on their land. Laws allowing small drones to fly at low altitudes over private parcels without landowners' permission would expose many formerly private spaces to open view, undermining these landowners' reasonable expectations.

The inequitable impacts of laws that would give behemoth corporations free access to millions of ordinary landowners' private airspace have likely further weakened public support for such policies. So long as landowners hold rights to exclude low-flying drones from their low airspace, they can potentially earn compensation for allowing drones to pass overhead.[52] By contrast, if FAA-authorized commercial drone operators could fly drones at very low altitudes over private land for free and without underlying landowners' permission, landowners would be unable to generate income by selling or licensing their airspace access rights. In essence, this latter approach would thus transfer billions of dollars in property entitlements from regular citizens to a handful of wealthy corporations—a result that is unlikely to generate fervent support from most landowners.[53]

II. Crafting Laws to Support Airspace Sharing Regimes for Drones

The commercial drone industry's recent efforts to secure free access to the country's low airspace have obscured an alternative approach to low airspace governance that would respect

[51] *See, e.g.*, Long Lake Township v. Maxon, *supra* note 18 at 7 (finding that "flying [drones] at legal altitudes over another person's property without permission or a warrant would reasonably be expected to constitute a trespass"). *See also* Biron, *supra* note 48 (quoting one professor as noting that most landowners "really believe they own everything above their property").

[52] A detailed description for such a potential regime is outlined in Part II. *See generally*, text accompanying notes 55–76, *infra*.

[53] For a more detailed discussion of the distributional impacts of a federal preemption approach to aerial trespass for drones, *see generally*, Troy A. Rule, *Entitlement-Shifting Rules*, 62 B.C. L. REV. 1193, 1246–48 (2021).

rather than ignore existing property laws. This alternate framework would leverage market forces and emerging technologies to create voluntary airspace-sharing systems that better balance drone-related uses of low airspace with landowners' uses of that space. Within these systems, individual landowners would voluntarily license their airspace to drone operators on a pennies-per-use basis through digital platforms to form temporary airspace corridors for commercial drone uses. The platforms would execute numerous smart contracts—prenegotiated airspace license transactions—in real time to create drone corridors, record these transactions in accessible ledgers, and automatically remit corresponding payments to underlying landowners.[54]

As the following sections describe, airspace sharing platforms are already technologically feasible and would offer multiple public policy advantages over the drone industry's preferred top-down approach to airspace governance. However, policy reforms would be needed at the federal, state, and local levels to enable such platforms to emerge in the United States.

A. The Basic Elements of a Property-Based Airspace Sharing System

The use of digital platforms to coordinate voluntary airspace sharing for commercial drones is much more than a fanciful pie-in-the-sky idea. Walmart has been examining potential uses of distributed ledgers for drone routing for years.[55] At least one company in the United States has even outlined a business plan for using blockchain to coordinate airspace sharing for drone flights. In 2017, the AERO Foundation described the potential for its AERO Token—an Etherium-based blockchain technology—to coordinate the granting of temporary avigation easements to drone

[54] For introductory information about smart contracts, visit the "Smart Contracts Defined" web page on IBM Corporation's website, available at https://www.ibm.com/topics/smart-contracts (last visited Dec. 28, 2021).

[55] *See* Nicholas Shields, *Walmart Is Exploring Blockchain for Drone Delivery*, BUSINESSINSIDER.COM (Sept. 5, 2018), https://www.businessinsider.com/walmart-blockchain-drone-delivery-patent-2018-9. Although Walmart's patent application for blockchain-assisted drone delivery routing systems did not expressly contemplate the coordination of avigation easement purchases, the company's interest in distributed ledger technologies in this context is evidence of major companies' interest in potential uses of the technologies in their drone operations.

service providers.[56] Using distributed ledger technologies, AERO's envisioned system would execute and record countless such transactions per day while building thousands of low-cost temporary flight routes for commercial drones. Although the specific attributes of future digital airspace sharing systems will evolve over time, they are likely to have a few basic features.

1. An Online Site Where Landowners Bid to License Airspace Access

A web page and corresponding smartphone app where landowners can make offers to license their airspace to drone users is an indispensable element of a digital airspace sharing regime. On this app and website, landowners would enter bids representing the lowest price they would be willing to accept to allow a single drone to cross above their property at certain times of day on specified dates or days of the week. As described immediately below, if structured properly, this "reverse auction" bidding model would harness market forces to drive down drone route prices to levels approximating landowners' true costs of having drones fly overhead.[57]

The basic functions of an airspace sharing system's app would mirror those of analogous platforms already in use within the sharing economy. Landowners throughout a community would first log on to the site and register through a process that would verify their identities and land ownership interests. Once registered, landowners could then begin entering reverse auction airspace sharing bids—minimum prices at which they'd be willing to *sell* temporary licenses on a per-crossing basis for commercial drones to fly through their airspace at specific times of the

[56] *See* Nanci K. Carr, *Look! It's a Bird! It's a Plane! No, It's a Trespassing Drone*, 23 J. TECH. L. & POL'Y 147, 180–81 (2019).

[57] The market-clearing price under a reverse auction model is usually the lowest bid price, whose price reflects the lowest amount a bidder in the auction is willing to accept to sell the auctioned asset. *See Online Auctions*, Executive Legal Summary 388 (2021) ("The basic idea of a reverse auction is that sellers go online and bid down the price of a particular commodity or product in order to provide the commodity or product to certain buyers. Usually, the lowest bidder wins; however, a buyer may choose a higher bidder based on other considerations, such as location, reputation of the seller, etc.").

day and week.[58] To assist bidders, the app could provide real-time information on recent winning bids within the relevant community in per-foot and per-crossing terms and allow them to regularly adjust their bids.[59] Through this system, landowners seeking to generate more income by attracting greater drone traffic through their airspace could do so by lowering their bids to beat their neighbors' bid prices. Conversely, landowners uninterested in generating income through airspace sharing could express that preference by posting above-market bids. For instance, a typical residential couple who both commute to work on weekdays would presumably be willing to submit much lower airspace sharing bids than a quiet spa resort with several outdoor pools.

Once enough landowners within a community have entered online bids through an airspace sharing system to license out temporary access to their airspace, registered commercial drone operators could begin using the same online platform to find and purchase drone flight routes.[60] For instance, if a pizza restaurant were to enter a specific destination address—much like customers routinely do on Uber's app—the platform would reveal distances, estimated roundtrip

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[58] Online reverse auction schemes already see heavy use in a variety of settings. *See, e.g.*, Philip L. Bruner & Patrick J. O'Connor Jr., *Reverse Auction Bidding*, 2A BRUNER & O'CONNOR CONSTRUCTION LAW § 7:124 (2021) (citing Ohara and Naja, Bechtel Corporation: *Online Bidding and Reverse Auction Program, Contained in Value-Based Contracting—It's Not Just Price Any More*, ABA FORUM ON THE CONSTRUCTION INDUSTRY (Oct. 2–3, 2003) (defining an online reverse auction as "a real-time dynamic process between a buyer and a group of prequalified, invited sellers who compete on-line to provide goods or services pursuant to clearly defined scope, specifications, and terms and conditions"); *see also* Susan L. Turley, *Wielding the Virtual Gavel—DOD Moves Forward with Reverse Auctions*, 173 Mil. L. Rev. 1, 3 (2002) (explaining that "in a reverse auction, the bidders are vying for the right to sell something to the auction holder").

[59] Similar features already exist in other online reverse auction systems. *See, e.g.*, id. (explaining that in reverse auctions for large construction contracts, "bidders do not see what others are bidding during the auction but receive immediate feedback on competitiveness of their last bid and have the opportunity to lower their last bid if they choose").

[60] Some drone companies, such as Alphabet's Wing, already have begun using software to identify optimal drone delivery routes. *See, e.g.*, Joann Muller, *The Drone Delivery Capital of the World*, AXIOS.COM (Aug. 27, 2021), https://www.axios.com/drone-food-delivery-australia-wing-alphabet-google-f11a8dc1-414e-4f68-a3cc-021a63662328.html (noting that "Wing's software chooses the optimal route" for drone-assisted deliveries in Logan, Australia).

flight times, and prices for various available routes to that location.[61] Those prices would reflect the sum of the bids of all underlying landowners along available routes to the selected destination for that specific date and time.

As a simple illustrative example, suppose that one possible drone route to deliver pizza to a nearby home crossed over twelve private parcels and that the owners of those parcels had each entered online bids of five cents. Based on these inputs, and assuming for simplicity's sake that they were the only components of the route price,[62] the airspace sharing app would show the total route price to be

12 x $0.05 = $0.60

Suppose further that an alternative route to the same home crossed over thirteen parcels, with ten of those landowners bidding five cents and three of them bidding four cents. The total price appearing on the app for this alternate route would be

(10 x $0.05) + (3 x $0.04) = $0.62

Faced with these two options, the pizza restaurant would likely select the first drone route. Once the restaurant made that selection, the platform would charge the operator's account and unlock instructions in the restaurant's Global Positioning System (GPS)–based drone flight navigation application to autonomously deliver the pizza using its drone.[63] The platform would

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[61] The process and requirements for creating location-based sharing apps like Uber are now relatively well established. *See, e.g.*, Anastasia Lastovetska, HOW TO MAKE AN APP LIKE UBER: COMPLETE GUIDE, MLSDEV.COM (Nov. 12, 2021), https://mlsdev.com/blog/how-to-make-an-app-like-uber (outlining in detail the basic elements of Uber's app, including geolocation features and payment gateway integration).

[62] In actuality, airspace sharing platform operators might add their own charges to route prices and collect those charges from drone operators upon their selection of each route. Rideshare companies such as Uber often use this model, collecting fees from drivers for each completed ride. *See, e.g.*, *How Can Pricing Serve Riders and Drivers?* UBER.COM, https://www.uber.com/us/en/marketplace/pricing/service-fee/ (last visited Dec. 29, 2021) (describing Uber's service fee structure). Airspace sharing platform operators could alternatively use a subscription-based revenue model and collect daily or monthly fees from drone operators for use of the platform.

[63] *See* Kenneth Maher, *Flying under the Radar: Low-Altitude Local Drone Use and the Reentry of Property Rights*, 15 DUKE L. & TECH. REV. 102 (2017) (noting that onboard GPS systems allow many modern drones to "automatically navigate to specific locations, orbit fixed points, carry out pre-drawn flight paths, or stay within certain preset boundaries").

also simultaneously use a payment gateway to remit airspace access payments to all twelve underlying landowners based on their winning bids.[64] Because all drone route prices would reflect underlying landowners' bids, this system would incentivize companies to avoid routing drones through drone-sensitive areas like the spa resort mentioned above and to instead route drones over less drone-sensitive parcels.

In communities that coordinate all drone routing through a single airspace sharing system, individual landowners could also potentially use the platform to purchase temporary "no-drone zones" around their properties. The same website or app landowners use to bid to host drone flights could have a separate feature allowing for such purchases. Through this feature, landowners seeking additional privacy for specific events, such as outdoor weddings or backyard parties, could pay to keep all commercial drones out of a specified radius of airspace around their parcel for specified periods of time. For instance, a person hosting a 3-hour pool party might be able to pay a modest price per hour through the app to keep commercial drones out of all airspace within a 1,000-foot radius of her parcel during that period. The per-hour pricing of these temporary no-drone zones would be based primarily on the average total airspace licensing revenues landowners within the radius would ordinarily earn during the specified period. While a no-drone zone was in effect, commercial drone deliveries would not be available within that zone and drone routes would automatically circumvent the area. This potential to temporarily acquire enhanced privacy from drones—privacy that extends beyond a single landowner's property boundaries—could be an additional benefit of airspace sharing and help to further build support for these regimes.

[64] Countless companies use third-party payment gateway services to process customer payments. *See* Dana Sitar & Rob Watts, *What's a Payment Gateway and How Does It Work?* FORBES.COM (Sept. 28, 2021), https://www.forbes.com/advisor/business/what-is-a-payment-gateway/.

2. Smart Contracts for Temporary Airspace Access

A second key feature of airspace sharing systems for commercial drones is their use of smart contracts to dramatically reduce system-related transaction costs. As highlighted above, soon after the emergence of manned aviation, US courts ruled that higher-altitude "navigable" airspace was a public highway for air travel.[65] A primary policy rationale for this rule was that requiring airlines to acquire avigation easements from every landowner lying below their plane's flight path would be so expensive that it would effectively preclude most air travel.[66] This concern remains valid today as it relates to manned aviation. Modern commercial airliners often travel hundreds of miles at a time, passing over thousands of separately owned land parcels per flight. Under a legal regime that vested landowners with exclusion rights in navigable airspace, the sheer number of airspace licensing transactions required to allow for cross-country flights would make most air travel cost-prohibitive.

Although airspace sharing regimes for last-mile drone-assisted deliveries would also involve many transactions per route, the total quantities of transactions involved are more likely to be in the dozens than in the thousands and thus could be reasonably managed through smart contracts. Smart contracts are contractual arrangements that automatically self-execute whenever specified conditions are met.[67] Using digital technologies to manage and record smart contracts dramatically reduces transaction costs by allowing transactions to occur even when one or more contracting parties are not present or directly involved. In the context of airspace

[65] *See supra* note 15 and accompanying text.

[66] *See* id.

[67] *See* Georgios Dimitropoulos, *The Law of Blockchain*, 95 WASH. L. REV. 1117 (2020) (defining a "smart contract" as a "self-executing 'contract,' whereby the terms of the agreement between the two parties are directly written into code, reducing transaction costs, and facilitating transactions without third-party intervention" and describing them as "a way of making an agreement that is fulfilled as soon as certain pre-determined conditions are satisfied" that can "be coded between any party in the world, independent of their physical location").

sharing, smart contracts could allow landowners to spend just a few minutes making offers to license their airspace only once a year or less and then collect revenue from thousands of transactions based on those offers.

A second category of transaction costs associated with assembling contiguous chains of airspace licenses for a commercial drone flight relates to what economists call holdout problems.[68] Holdout problems are commonly associated with developments of new roads, pipelines, or major real estate projects that necessitate the assembly of many contiguous and separately owned parcels.[69] In these settings, some parcel owners may be tempted to extract some of the project's assembly value for themselves by "holding out" and demanding very high prices in exchange for their interests.[70] This risk is a frequently cited justification for laws vesting governments with eminent domain authority—the power to unilaterally acquire private property for public use upon payment of just compensation.[71]

Within an airspace sharing regime for drones, governments could similarly exercise their eminent domain authority when necessary to combat holdout problems among landowners. In particular, municipalities could condemn public avigation easements above private parcels to create open-access drone corridors in certain bottleneck locations where drone access is needed most. Governments have been exercising eminent domain powers to take avigation easements for roughly a century to secure flight paths near airports.[72] Condemning easements for drone

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[68] *See* Thomas J. Miceli & C. F. Sirmans, *The Holdout Problem, Urban Sprawl, and Eminent Domain*, 16 J. HOUS. ECON. 309, 310 (2007).

[69] *See* id.

[70] *See* id.

[71] *See, e.g.*, Steven Shavell, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 124–25 (2004) (explaining that eminent domain can help governments to overcome holdout problems in projects that require land assembly); Thomas W. Merrill, *The Economics of Public Use*, 72 CORNELL L. REV. 61, 75 (1986) (characterizing eminent domain as a means of mitigating holdout problems in public projects requiring the assembly of multiple privately held parcels).

[72] *See* Troy A. Rule, *Airspace and the Takings Clause*, 90 WASH. U. L. REV. 421, 428–29 (2012).

corridors would be no different and would satisfy the Takings Clause's "public use" requirement so long as the acquired easement pathways were accessible to all licensed drone users operating as common carriers.[73]

State legislatures could even consider enacting compulsory airspace licensing statutes to limit holdout problems under an airspace sharing system for drones. Compulsory unitization or compulsory pooling laws have helped to mitigate holdout problems in the oil and gas drilling context for decades by compelling holdout landowners to participate in unitization or pooling arrangements that promote more efficient oil and gas extraction.[74] Legal rules likewise allow for the compulsory licensing of certain intellectual property in narrow settings when it is needed to advance important public policy goals.[75] In the context of airspace sharing, analogous laws could compel landowners who refused to enter licensing bids for their low airspace to license that space at a government-stipulated price in rare instances when the space above their parcel is one of a few needed to complete a particular drone route. The mere threat of such compulsory airspace licensing could persuade some holdout landowners to register and enter bids.[76] Such compulsory licensing laws would weaken landowners' airspace exclusion rights, but they would

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[73] *See* Alexandra B. Klass, *Takings and Transmission*, 91 N.C. L. REV. 1079, 1095 (2013) (noting that "virtually every state has statutes granting eminent domain authority to power companies, railroads, and other common carriers").

[74] *See* Jacqueline Lang Weaver, *The Tragedy of the Commons from Spindletop to Enron*, 24 J. LAND RESOURCES & ENVTL L. 187, 187 (2004) (noting that all major oil-producing states except Texas have enacted compulsory unitization laws).

[75] *See* James Gibson, *Re-reifying Data*, 80 NOTRE DAME L. REV. 163, 226–27 (2004) (characterizing compulsory licensing as a "subset of the liability rule approach" to property protection, and explaining that "intellectual property law usually uses compulsory licenses in contexts in which the costs of negotiating individual licenses are thought to be so high as to foil an otherwise welfare-enhancing transaction" or when needed to "achieve a redistribution of wealth or other resources that would not occur in an unregulated market").

[76] *See* Gary D. Libecap & James L. Smith, *The Economic Evolution of Petroleum Property Rights in the United States*, 31 J. LEGAL STUD. 589, 596 (2002) (noting that "the threat of invoking [compulsory unitization laws for oil and gas extraction] may reduce bargaining costs if it mitigates the holdout problem" and adding that "for the threat to be effective, it has to be credible, which requires the state to follow through with compulsory unitization at least in some cases").

still leave landowners far better off than under a governance structure that gives FAA-authorized drone operators access to that same airspace for free.

B. The Policy Advantages of Property-Based Airspace Sharing for Drones

Using property law, digital technologies, and market forces to coordinate airspace sharing in the drone age would not only be feasible, but it would also have multiple public policy advantages over the drone industry's preferred approach of ignoring landowners' airspace rights. Many of the types of social welfare gains achievable through airspace sharing systems are already being realized in more-established areas of the *sharing economy*—the nation's growing set of "practices and techniques that leverage[s] digital architectures to facilitate trusted transactions between strangers."[77] Sharing economy platforms such as Uber and Airbnb dramatically reduce transaction costs in ways that allow individuals to generate additional income by lending their underused assets and resources to others.[78] In the process, these platforms can also promote more efficient allocations of resources and reduce market prices for shared assets.[79]

Applying time-tested sharing economy technologies and models to coordinate commercial drone routing in the nation's low airspace could provide many public policy advantages. The following are descriptions of three significant potential societal benefits of relying on property laws rather than broad FAA authorizations to govern airspace uses in the era of commercial drones.

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[77] Ryan Calo & Alex Rosenblat, *The Taking Economy: Uber, Information, and Power*, 117 COLUM. L. REV. 1623, 1634 (2017).

[78] *See* Yochai Benkler, *Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production*, 114 YALE L.J. 273, 297 (2004).

[79] *See* Bryan Cannon & Hanna Chung, 31 SANTA CLARA HIGH TECH. L.J. 23, 31 (2015) (explaining that the "digital-sharing economy generally facilitates more efficient allocation of existing resources" and can "allow access to goods and services at a lower cost").

1. More Efficient Use of the Nation's Low Airspace

One major potential advantage of property-based airspace sharing would be more optimal use of the nation's increasingly valuable low airspace resources. Like many locally regulated activities, commercial drone flights impact some types of land uses more than others: a pattern of frequent drone flights over an area of empty warehouses is likely to impose fewer costs on landowners than a similar pattern of flights over a quiet residential neighborhood.[80] A governance regime that gives FAA-authorized drone operators blanket licenses to fly over either of these types of land uses at their own discretion—for free—does not require drone users to internalize any of those landowner costs and is thus more prone to allocative inefficiency.[81]

A simple numeric example illustrates the valuable function airspace sharing systems could play in allocating airspace use in the drone age. Suppose hypothetically that frequent drone flights over a tranquil destination spa resort would impose $10,000 in annual costs on the resort's owners. Suppose further that the same frequency of drone flights over an industrial warehouse complex nearby would impose only $100 in annual costs on that facility's owners. However, routing drones over the warehouse instead of over the resort would require slightly longer routes for commercial drone users in the community, adding a few seconds to most retail delivery times and thereby costing these companies a total of about $10 per year. Under a governance regime in which FAA-authorized drones could fly over nearly any private land for free, commercial drone users would internalize none of the landowner cost differences between these two routes and thus rationally choose to routinely fly over the resort—a highly inefficient outcome.[82] If the same

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[80] *See* Rule, *Drone Zoning*, *supra* note 21 at 161 (analogizing to local land use regulation to emphasize the benefits of allowing more localized governance of most drone activities).

[81] *See* Dominic J. Brewer & Lawrence Picus, ENCYCLOPEDIA OF EDUCATION ECONOMICS & FINANCE 54–56 (SAGE, 2014) (explaining that allocative efficiency "occurs when markets optimally distribute goods and services taking into account consumers' preferences").

[82] Specifically, the net social welfare cost of drone user's decision to route drones over the resort and not over the warehouse would be [($100 – $10,000) + $10] = –$9,890.

parties were instead operating under a well-functioning airspace sharing system, the resort's much-higher bids to share its airspace would have led drone users to fly over the warehouses instead. By harnessing market forces in this way, airspace sharing regimes would automatically keep drones away from areas where they are the most disruptive and route them over parcels where they are less bothersome.

2. More Equitable Distribution of Airspace-Related Wealth

Routing commercial drones through airspace sharing systems would also result in a more equitable distribution of low airspace-related wealth in the drone age than would result under the drone industry's preferred FAA authorization structure. Concerns about economic inequality and the rising concentration of wealth and power among corporations and the very richest Americans have intensified in recent years.[83] The country's two largest corporations—Amazon and Walmart—have profited handsomely during the COVID-19 pandemic and are poised to be major players in the nation's commercial drone industry.[84] Policies giving broad federal drone flying authorizations to commercial drone users would only worsen this equality gap, stripping tens of

[83] *See, e.g.*, Christopher Ingraham, *Wealth Concentration Returning to "Levels Last Seen during the Roaring Twenties," according to New Research*, WASH. POST (Feb. 8, 2019), https://www.washingtonpost.com/us-policy/2019/02/08/wealth-concentration-returning-levels-last-seen-during-roaring-twenties-according-new-research/ (reporting that the "400 richest Americans—the top 0.00025 percent of the population—have tripled their share of the nation's wealth since the early 1980s"); Miriam H. Baer, *Three Conceptions of Corporate Crime (and One Avenue for Reform)*, 83 LAW & CONTEMP. PROBS. 1, 17 (2020) (describing growing concerns about "concentrations in wealth and corporate power, as well as rising economic inequality and reduced social mobility").

[84] *See* Molly Kinder & Laura Stateler, *Amazon and Walmart Have Raked in Billions in Additional Profits during the Pandemic, and Shared Almost None of It with Their Workers*, BROOKINGS.EDU (Dec. 22, 2020), https://www.brookings.edu/blog/the-avenue/2020/12/22/amazon-and-walmart-have-raked-in-billions-in-additional-profits-during-the-pandemic-and-shared-almost-none-of-it-with-their-workers/ (reporting that in 2020, "Amazon and Walmart, the country's two largest companies . . . earned an extra $10.7 billion over [2019's] profits during (and largely because of) the pandemic—a stunning 56% increase"). *See also* Alan Boyle, *Taking the Spotlight from Amazon, Walmart and DroneUp Set Up Drone Delivery Hubs in Arkansas*, GEEKWIRE.COM (Nov. 22, 2021), https://www.geekwire.com/2021/taking-the-spotlight-from-amazon-walmart-and-droneup-set-up-drone-delivery-hubs-in-arkansas/ (noting that "Walmart aims to become the leader in drone deliveries" and quoting an Amazon spokesperson's statement that Amazon "Prime Air is committed to making our goal of delivering packages by drones a reality").

millions of Americans of their long-held airspace rights and redistributing those valuable entitlements to the nation's wealthiest companies.[85] By contrast, a property-based airspace sharing structure would entitle those tens of millions of ordinary landowners to compensation for drone flights through their airspace, supplementing their income and distributing the economic benefits of airspace sharing among a much broader subset of the citizenry.

Although some American apartment renters might be worse off under an airspace sharing system than under a top-down FAA-authorization system for commercial drone routing, on the whole an airspace sharing system would likely still produce more equitable distributions of wealth. An airspace sharing system would compensate landowners in proportion to the number of drone overflights occurring within their airspace, and much of that compensation would likely get passed on to the retail customers receiving drone deliveries. Americans living in multistory apartment buildings are not landowners and would thus be unable to generate airspace-licensing income to offset those higher delivery fees. Meanwhile, those same renters would likely pay higher goods delivery fees as retail consumers.[86] However, enabling landlords to generate additional income through airspace licensing could lead to slightly lower apartment rental rates in competitive residential market environments. Moreover, even if landlords kept most airspace licensing revenues rather than pass them along to tenants, overall distributions of low airspace-related wealth would still be broader and more equitable under an airspace sharing system than under a top-down authorization regime that transferred low airspace access rights to large corporations.

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[85] *See* Rule, *Entitlement-Shifting Rules*, *supra* note 53 at 1246–48.

[86] Apartment renters typically hold no airspace rights because they do not hold title to surface rights. *See* Allison O. Mahr, *Property*, 21 N.M. L. REV. 697, 705 n. 103 (1991) ("When a landlord leases property to a tenant, a landlord retains a reversionary interest in the property and continues to hold the seisin (or title to the property) throughout the leasehold's duration") (citing 2 R. Powell, THE LAW OF REAL PROPERTY ¶ 248 (1991)).

For leases of raw land or of single-story or single-tenant buildings, state legislatures could potentially promote greater equity by enacting laws expressly providing that such leaseholds include airspace exclusion rights. Such statutes would empower tenants to act like landowners and license the airspace above the leased premises based on their own preferences throughout the lease term.

In multistory buildings with multiple tenants, parties could likewise use private contractual arrangements to promote more equitable sharing of airspace interests. For example, provisions in a condominium's declaration documents could vest authority to make airspace sharing decisions with the condominium association's elected board, and provide that all revenues generated through licensing of that space to drone users be deposited in the association's account.[87] And in the case of rented multistory apartment buildings, lease provisions could vest airspace sharing authority with the landlord but require that any and all revenues earned through such airspace sharing be remitted proportionately to tenants on a per-square-foot basis to offset their rental obligations. Such provisions would help mitigate externality problems that might otherwise motivate landlords living off-site to seek supplemental revenue by using low bids to attract high volumes of drone flights over their rental properties.[88]

3. Greater Public Acceptance and Accelerated Drone Industry Growth

One other notable benefit of routing drones through airspace sharing regimes would be greater public buy-in, which could ultimately promote a faster rollout of commercial drone services

[87] Comparable structures already exist for community solar projects built on the rooftops of condominium buildings. *See Virtual Net Metering: Solar for Condos*, CENTER FOR SUSTAINABLE ENERGY, https://sites.energycenter.org/solar/multifamily/toolkits/condos (last visited Dec. 8, 2021).

[88] Specifically, landlords living off-site would not internalize the costs of drone flights over the leased premises but would receive the airspace licensing revenues from those flights and thus have incentives to attract suboptimally high amounts of commercial drone activity above their leased premises. For a general explanation of externalities and their impacts, *see generally*, James R. Kearl, PRINCIPLES OF ECONOMICS 412–428 (D. C. Heath, 1993).

across the country. As highlighted above, many American landowners rightfully believe they have rights to exclude unwanted objects from the low airspace above their land, and their opposition based on this view has already slowed US commercial drone industry growth.[89] Airspace sharing regimes that financially reward landowners for voluntarily licensing their airspace to commercial drone companies would mitigate this opposition by recognizing landowners' airspace rights and incentivizing them to benefit financially by licensing those rights.

By decentralizing drone routing governance, airspace sharing regimes could also allow for more experimentation and thereby accelerate innovation and industry growth. By analogy, laws vesting subsurface mineral rights in private landowners and sparing those resources from heavy federal government control have helped the United States be a world-leading innovator in oil and gas extraction over the past century.[90] Laws reaffirming private ownership of low airspace rights and empowering state governments, localities, and the private sector to develop governance structures for the sharing of low airspace resource could ultimately produce similar positive effects for the nation's commercial drone industry.

Ironically, Amazon—a strong advocate of top-down preemption approaches to airspace governance—might enjoy sizable competitive advantages under an airspace sharing system model. Having already amassed more than 150 million Americans as Amazon Prime subscribers, the company would have unmatched leverage in persuading landowners to register on an airspace sharing app and enter their bids.[91] For instance, Amazon could offer discounted Prime

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[89] *See supra* note 51 and accompanying text.

[90] *See* Thomas W. Merrill, *Four Questions about Fracking*, 63 CASE W. RES. L. REV. 971, 977–81 (2013) (arguing that property law regimes in the United States that recognize private ownership of subsurface mineral rights and that largely allow states rather than the federal government to regulate onshore oil and gas production have helped to drive greater innovation in that industry).

[91] *See* Don Davis, *Most Amazon Shoppers Only Have Eyes for Amazon*, DIGITALCOMMERCE360.COM (Nov. 3, 2021), https://www.digitalcommerce360.com/article/amazon-prime-membership/.

memberships for customers who register and enter airspace sharing bids for their parcels in communities where the company is preparing to roll out drone delivery services. The company could even require customers in these target communities to register and enter bids as a condition to renewing their Amazon Prime subscriptions or to receiving drone-assisted Amazon deliveries. If Amazon were to leverage these sizable advantages to become a major airspace sharing platform provider, the company could eventually generate new revenue streams by collecting subscription or per-flight fees from other retailers seeking to make drone-assisted deliveries. Unfortunately, to date, Amazon has shown no interest in pursuing this more equitable and efficient alternative approach.

C. A Policy Structure for Property-Based Airspace Sharing

Policy reforms at the federal, state, and local government levels could do much to promote the development of property-based airspace sharing platforms for commercial drones. Among other things, such reforms could resolve lingering questions about drone regulatory jurisdiction, affirm and clarify landowners' airspace rights, and empower municipalities to provide localized regulation through drone zoning ordinances. Collectively, these policy changes could finally unleash rapid growth for commercial drone applications throughout the country.

1. Clarifying the Bounds of Federal Drone Regulatory Jurisdiction

Airspace sharing platforms for drones are unlikely to emerge in the United States until Congress or the FAA place clearer limits on the federal government's regulatory jurisdiction over civilian drone activities. Uncertainty regarding the scope of the FAA's drone regulatory authority continues to slow commercial drone innovation and growth in the United States. Reducing this uncertainty by expressly recognizing substantial state authority over drone routing is a critical step toward encouraging the development of property-based airspace sharing systems.

As already outlined in detail in a previous article, the federal government is best suited to fulfill a variety of important drone regulatory roles.[92] Among other things, uniform federal drone manufacturing and performance standards are needed to ensure that drone manufacturers do not have to comply with a patchwork of state manufacturing requirements and that commercial drones throughout the country obey geofences and have other important compatibility features.[93]

Congress has rightly empowered the FAA with regulatory authority over civilian drone activities that reasonably could impact or create hazards for conventional manned aviation in navigable airspace.[94] The federal government has legitimate interests justifying continued federal registration and remote identification requirements for civilian drones.[95] And the federal government has clear regulatory jurisdiction over drone activities in low airspace above federally owned lands or in locations that implicate significant national security risks.[96]

As a policy matter, however, it is difficult to justify federal regulatory jurisdiction over commercial drone activities in low airspace that have little to do with national interests or manned aviation safety. States and local governments have historically been the primary regulators of most activities within this space. Like land use planning and zoning, commercial

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[92] *See generally*, Rule, *Drone Zoning*, *supra* note 21 at 163–68.

[93] *See* id. at 163–66.

[94] *See* 49 U.S.C. §§ 40103, 40104 (2012) (outlining the FAA's regulatory authority over air commerce). Courts are only beginning to clarify the scope of the FAA's jurisdiction over low-flying drones under these authorizing statutes. *See, e.g*., Singer v. City of Newton, 284 F. Supp. 3d 125, 130 (D. Mass. 2017) (holding that "the FAA explicitly contemplates state or local regulation of pilotless aircraft, defeating [the] argument that the whole field is exclusive to the federal government"); Nat'l Press Photographers Assoc. v. McCraw, 504 F.Supp.3d 568, 589 (2020) (finding that "federal law has not completely preempted the field regarding UAVs flying over certain buildings and structures" and finding insufficient evidence "that Congress intended to prohibit states from passing additional regulations related to UAVs, even ones related to existing FAA regulations").

[95] A final FAA Rule governing many remote identification matters for drones became effective in April 2021. For an accessible explanation of these relatively new rules, *see generally*, *UAS Remote Identification Overview*, Fed. Aviation Admin., FAA.GOV (Oct. 13, 2021), https://www.faa.gov/uas/getting_started/remote_id/ (last visited Dec. 9, 2021). For a discussion of why it is arguably justifiable to impose and enforce such rules at the federal government level, see Rule, *Drone Zoning*, *supra* note 21 at 166–67.

[96] *See* Rule, *Drone Zoning*, *supra* note 21 at 167–68.

drone routing in low airspace is an inherently location-specific endeavor that is well suited for local oversight, except in narrow situations involving specific federal interests.

A new federal statute recognizing broad state-level jurisdiction over commercial drone routing could accelerate the emergence of airspace sharing systems, but only if that legislation created no new layer of federal open-access airspace. The most recent federal bills seeking to clarify low airspace jurisdiction would only prohibit the FAA from regulating most drone activities within 200 feet of the ground.[97] Unfortunately, for reasons articulated below, such a 200-foot dividing line would fail to adequately preserve landowners' airspace exclusion and privacy interests and would likely prevent the emergence of viable airspace sharing regimes.[98]

Federal legislation declaring that airspace within 400 feet of the ground was within state regulatory jurisdiction and that the 100-foot-wide layer of space between the altitudes of 400 and 500 feet is not legally accessible by airplanes or by drones would greatly support the emergence of airspace sharing regimes. The legal certainty resulting from such laws would promote more private investment in property-based airspace sharing systems and encourage states and municipalities to assume greater roles in building regulatory structures to support these systems.

2. Strengthening Aerial Drone Trespass Laws through State Legislation

State legislatures could further assist in the emergence of airspace sharing platforms by enacting legislation affirming that landowners are generally entitled to exclude tangible objects—including

[97] *See generally*, DRONE INTEGRATION AND ZONING ACT, S. 600—17th CONGRESS (2021–22), https://www.congress.gov/bill/117th-congress/senate-bill/600/text (defining the "immediate reaches of airspace" for purposes of drone regulation to comprise only the first 200 feet above the ground). *See also* Note, *Drone Trespass and the Line Separating the National Airspace and Private Property*, 86 Geo. Wash. L. Rev. 115 (2018) (advocating for the FAA to designate all airspace within 200 feet of the surface as private property).

[98] *See infra* notes 100–103 and accompanying text.

drones—from the first 400 feet of space directly above their land. Provisions within such legislation could likewise make clear that these airspace rights are appurtenant to surface rights and that unauthorized invasions into such space constitute actionable trespasses. These statutes could also affirm that the same general exceptions for necessity, emergencies, and other extenuating circumstances applicable under the common law to trespass to land apply to aerial trespasses. These statutory provisions could even declare that landowners' low airspace rights are subject to federal regulatory powers but only to the extent necessary to protect the safety of manned aviation within navigable airspace and near airports.

State statutes governing aerial drone trespass in low airspace have arguably been well within the scope of states' jurisdiction for a very long time, and laws recently enacted in more than one state are further evidence that states recognize their own regulatory power within this area. A statute enacted in Nevada a few years ago creates civil liability for any drone flights at altitudes less than 250 feet above private land conducted after the underlying landowner has objected.[99] Oregon's legislature has likewise enacted a statute entitling landowners to recover treble damages for injuries caused by unwelcome drones flying less than 400 feet above private land.[100] The enactment of such laws at the state level is fully consistent with an established body of state-level statutory and common law governing overhang encroachments and various other conflicts involving low airspace.[101]

State legislation declaring that landowners' drone exclusion rights extend up to 400 feet—rather than 200 feet or some other lesser height—would enable airspace sharing platforms to

[99] *See* NEV. REV. STAT. ANN. § 493.103 (2015).

[100] *See* OR. REV. STAT. ANN. § 837.380 (2016).

[101] *See* Rule, *Drone Zoning*, *supra* note 21 at 151–52 (using several examples to describe "states' and municipalities' long histories of regulating activities in the low-altitude airspace where small civilian drones fly").

preserve existing levels of landowner privacy. As stated above, early versions of the ULC's model state-level drone legislation proposed to limit landowners' airspace rights to just 200 feet above the ground,[102] and some federal bills drafted in recent years would have capped landowners' rights to that height.[103] Unfortunately, as even some ardent drone industry advocates have emphasized, a "drone operating at 201 feet can take the same pictures as a drone at 199 feet."[104]

In an age when drones with modern camera zoom lenses are inexpensive and widely accessible, clearly defining exclusion rights to reach up to 400 feet is the only way to genuinely preserve existing levels of landowner privacy as civilian drone activities proliferate across the country.[105] When combined with federal laws requiring manned aircraft to stay above 500 feet in most places and requiring that drones stay below 400 feet, such laws would finally establish a clear legal framework for the safe and publicly acceptable coexistence of drones and airplanes. Under such rules, manned flights above 500 feet would continue to enjoy legal protections from drones and drone-related disruptions, and the FAA's pilot licensing and other requirements associated with such flights would continue to limit the landowner privacy risks associated with them. Space below 400 feet would likewise host a wide range of valuable civilian drone activities, subject only to underlying landowners' exclusion rights, local drone zoning laws, and federal restrictions reasonably needed to protect manned aviation. And the 100-foot-wide layer of space sandwiched between these two domains would be an important "anticommons"—an

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[102] *See* Biron, *supra* note 48.

[103] *See, e.g.*, DRONE INTEGRATION AND ZONING ACT, *supra* note 97.

[104] Joshua S. Turner & Sara M. Baxenberg, *Clearing the Air: ULC Rightfully Rejects Property Rights Advocates' Line in the Sky*, 33 NO. 3 AIR & SPACE LAW. 1, 9 (2020).

[105] *See* Kristen M. J. Thomasen, *Beyond Airspace Safety: A Feminist Perspective on Drone Privacy Regulation*, 16 CAN. J. L. & TECH. 307, 318–19 (2018) (arguing that "since drones can be purchased at relatively low costs (depending on the sophistication of the device), and are easily accessible on the consumer market, they can be put to wide-scale use by a variety of operators" that "can combine to create a 'panoptic' chilling effect on individuals on the ground below").

area off limits to both types of flying machines that would serve as a valuable buffer to limit conflicts between drone activities and manned aviation activities.[106]

State legislatures could further aid the build-out of airspace sharing systems by expressly delegating to municipalities the power to adopt drone zoning ordinances. Although zoning enabling legislation enacted in all states arguably already empowers local governments to regulate drone activities in low airspace, clear new statutory delegations of drone zoning authority would provide greater legal certainty regarding these powers.[107]

3. Integrating Municipal Drone Zoning Ordinances into Airspace Sharing Systems

Municipal drone zoning ordinances could provide one other important layer of regulatory support for airspace sharing systems in the United States. Drone operations' impacts on underlying land uses vary greatly by location.[108] Drone zoning ordinances—modeled after land use zoning ordinances and consisting of legislated text and an overlay drone zoning map—seek to account for these differences by imposing restrictions on drone activities that vary by location throughout a municipality. Municipal government officials tend to be relatively well suited to develop and adopt local drone zoning plans and policies because of their localized knowledge of the distinct attributes and preferences of the communities they serve.

Drone zoning ordinances could play valuable roles in helping airspace sharing systems to promote the efficient use of low airspace in the drone era. Among other things, these ordinances could require airspace sharing systems to integrate drone zoning provisions and maps into their

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[106] *See generally*, Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998) (defining an "anticommons" as a resource for which "everyone has the power to exclude everyone else from a resource").

[107] *See* Rule, *Drone Zoning*, *supra* note 21 at 176 (stating that "municipalities, holding land use regulatory authority under state zoning enabling acts, are arguably authorized under those same statutes to regulate activities in the airspace just above the ground as well").

[108] *See* id. at 176–77.

platforms to ensure that commercial drone activities comply with local zoning laws. In neighborhoods where drone zoning ordinance provisions allow for fewer drone overflights, landowners would have greater peace and privacy but less capacity to generate income through the leasing or licensing of their airspace.

States and municipalities could potentially generate additional revenue by licensing the airspace above government roads and other land through airspace sharing systems as well. Government-owned streets, sidewalks, parks, buildings, and other improvements occupy a significant fraction of the land area in many communities.[109] States and localities might opt to establish open-access drone-flying corridors at specified altitudes above some of this government-owned land. Such above-road access could also mitigate holdout problems because existing property and land use laws ensure that nearly every parcel has legal access via a public right-of-way.[110] Above some other public land, governments might find it worthwhile to participate as landowners within airspace sharing systems and make offers to temporarily license this government-owned airspace for drone operations.[111] Statutory laws in some states arguably already empower states and some municipalities to enter into such agreements.[112]

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[109] Publicly owned streets, sidewalks, and other spaces account for a third to nearly half of the total land area in many US cities. *See* Gregory Scruggs, *How Much Public Space Does a City Need?* NEXTCITY.ORG (Jan. 7, 2015), https://nextcity.org/urbanist-news/how-much-public-space-does-a-city-need-UN-Habitat-joan-clos-50-percent (reporting that public roads and spaces comprise 49 percent of the land area in New York City and citing a United Nations report recommending that public places account for 45–50 percent of a city's land).

[110] For a discussion of holdout problems, see text accompanying notes, 68–76 *supra*.

[111] A law journal student note published in 2020 expressly advocates this idea. *See generally*, Daniel Thompson, *Rethinking the Highway: Integrating Delivery Drones into Airspace above Highways*, 95 IND. L.J. SUPPLEMENT 8 (2020). *See also* Brent Skorup, *Drone Technology, Airspace Design, and Aerial Law in States and Cities*, 56 AKRON L. REV. (forthcoming 2022) (arguing for governments' leasing of airspace above public roads for drone flight corridors).

[112] Some state legislatures have already enacted laws expressly permitting the state government or even municipal governments to lease the airspace above public roads to private entities. *See* Brent Skorup & Connor Haaland, WHICH STATES ARE PREPARED FOR THE DRONE INDUSTRY? A 50-STATE REPORT CARD, RELEASE 2.0 at 5–6, Mercatus Center at George Mason University (2021) (describing laws in seven states that allow states and local governments to lease the airspace above state or local public roadways to private parties and laws in another 16 states allowing such leasing only above state-owned roads). States and localities could alternatively opt to create free, open-access drone corridors at specified altitudes above some roads or other government-owned land.

Conclusion

Landowners' rights to exclude drones from the low airspace above their land need not prevent widespread commercial drone activities from emerging in the United States. Despite drone industry advocates' insistence otherwise, landowners continue to hold exclusion rights in the low airspace above their parcels under state property laws, and recent judicial decisions suggest that courts are unlikely to abandon these laws to make way for drones anytime soon. Fortunately, however, recent advancements in distributed ledger systems and other digital technologies have introduced viable ways to open much of the nation's low airspace to commercial drone services while still respecting landowners' property rights. With appropriate policy support at the federal, state, and municipal levels, such property-based airspace sharing systems could generate the economic incentives, public buy-in, flexibility, and coordination assistance needed for commercial drone services to finally take flight in the United States. Like the Wright brothers and other visionary pioneers across aviation's history, today's commercial drone industry has an opportunity to build futuristic and daring new platforms that could directly benefit millions of Americans. Embracing landowner airspace rights laws and building drone routing systems and business models around them could be the crucial step these companies need to finally make their vision a reality.