



# Drone Policy and Industrial Policy in the United States and China: Comparisons and Recommendations for American Lawmakers

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The United States and China have strong technology sectors and large consumer markets,<sup>1</sup> but their systems of government and public policy are very different. Taking note of the significant opportunities in drone manufacturing and services in both domestic and foreign markets, both nations' regulatory bodies have responded to the maturation of the commercial drone industry. Policy competition is emerging alongside industry competition in these sectors and will grow as companies in agriculture, parcel delivery, inspections, and medicine test and adopt drone services. Several drone pilot programs and initiatives have popped up in recent years across the United States at companies and at federal agencies. We see a need to translate Chinese regulatory documents and news stories for a US audience, summarize US drone programs, and compare the industries and regulations of the two countries.

The Civil Aviation Administration of China (CAAC) set out guidelines in January 2019 for drone airworthiness standards for civilian drones.<sup>2</sup> The CAAC also released proposed plans in May 2019 for the 30-year development of the unmanned civilian aircraft industry.<sup>3</sup> These proposed plans, while broad and general, highlight unmanned civilian aircraft such as drones and passenger drones as one of the future pillars of the Chinese economy, alongside areas such as artificial intelligence and 5G. These are the industries in which the Chinese government wants China to surpass Western countries' capabilities in the "fourth industrial revolution."

What jumps out from these translated documents is how Chinese regulators perceive their nation as lagging the United States and Europe in traditional commercial aviation. That perception seems to serve as a motivation to leapfrog the West and lead the globe in developing commercial drone, electric vertical takeoff and landing (eVTOL), and urban air mobility (UAM) standards and services.

US regulators likewise have plans and policies to jump-start a domestic commercial drone services industry.<sup>4</sup> There is substantial commercial interest: almost 350,000 commercial drones are registered today. US aviation regulators have planned a long-distance “concept of operations” and “maturity level” progression of technology and policy for small and large drones,<sup>5</sup> and these plans are not as rigid as the CAAC’s 30-year plans. Although long-distance drone operations in the United States today require time-consuming and revokable regulatory waivers that make operators’ investments more uncertain. However, in January 2021, the Federal Aviation Administration (FAA) formulated new rules to allow routine long-distance drone operations.<sup>6</sup> That small drone manufacturing has largely moved to China in the past decade is not lost on US lawmakers, and US regulators are eager to avoid a repeat of that movement for large freight and passenger drones.

In this policy brief, we survey Chinese and US drone regulations and policies. Broadly speaking, the large drone industry—freight and passenger drones—appears to be advancing more quickly in China, whereas small drone services appear more widespread and mature in the United States. On the whole, Chinese drone regulations preserve significantly more discretion for national regulators (and uncertainty for industry). The US regulatory environment currently suffers from a system of ad hoc and temporary waivers for long-distance drone operations, but US regulators appear prepared to apply more rigorous and general policies in the near future.

We provide recommendations to American federal and state lawmakers for promoting freight and passenger drone services domestically. Specifically, we urge US regulators to develop their drone corridor proposal and to apply a leasing or auction regime to this public asset. Federal and state lawmakers also need to formalize their roles regarding regulation of surface airspace. Finally, federal and state regulators should promote “drone sandboxes”<sup>7</sup>—inviting drone services companies to use public property and airspace for testing new drone services.

## **CHINESE NATIONAL POLICIES AND REGULATIONS**

In the past two years, the CAAC has drafted, trialed, and finalized regulations for civilian drone use. The CAAC, in conjunction with other relevant authorities, has also set up test areas—what we call drone sandboxes—across the country for the testing of drone systems and operating processes. On the regulatory side, the CAAC has implemented or run trials of many all-encompassing regulatory programs. These advances roughly follow the CAAC’s proposals for developing the drone industry, which we first described in 2019.<sup>8</sup> The following sections examine some of the CAAC’s new regulatory approaches.

In 2019, the CAAC began issuing procedures and requirements for certification of three types of unmanned aerial vehicles (UAVs): drones with takeoff weights between 25 and 150 kilograms, those with weights between 7 and 25 kilograms with a “high operational risk,” and those with weights greater than 150 kilograms with a low operational risk.<sup>9</sup> In 2020 and 2021, the CAAC con-

ducted trials on a complete set of design specifications, production approvals, and airworthiness certifications for drone manufacturers and operators. The regulations described in the following sections are mostly in trial or open commentary phases, which gives the CAAC and other governing bodies flexibility to change the regulations. Our interpretation and analysis suggest that this flexibility is in part intended to preserve regulator discretion to identify promising technology and later promote national champions.<sup>10</sup>

### Airworthiness Regulations

As part of a May 2020 release of a drone airworthiness trial guidance,<sup>11</sup> the CAAC included both (a) airworthiness certification procedures and (b) a risk assessment guide. The trial ended on June 1, 2021, and, at the time of this writing, there is no further information from the official CAAC sources on trial results.

The procedures and the guide cover approval for UAV system design, production, and operation. For airworthiness certification, authorities consider a potential drone operator's organizational, process, and resource management.<sup>12</sup> Regulator assessment of a company's internal management competence has little parallel in American drone regulations.

This CAAC drone airworthiness certification process uses a risk-based certification system, and procedures differ depending on the drone system's risk level. The CAAC seeks to standardize its airworthiness certification with its trial risk assessment.<sup>13</sup> Risk level—rather than strict weight class—determines the set of procedures an applicant follows and the CAAC's level of involvement.

The trial risk assessment guide divides drones into low-, medium-, and high-risk categories. There are three different components of determining risk: management system risk, kinetic energy level, and collision risk. The applicant-operator's management system risk (管理体系风险) includes business characteristics such as personnel management, training, and facilities. Kinetic energy level (能量等级) pertains to maximum-performance takeoff and level flight. Finally, collision risk is determined by operations characteristics such as whether the operator intends to fly over an air corridor, over a densely populated area, or near a manned aircraft. Collision risk and kinetic energy level are aggregated to form product risk, which is evaluated with management system risk to determine an overall risk level.

The riskier a system, the more the CAAC intervenes in the certification process. For low-risk systems, the applicant performs most of the compliance work and the CAAC only reviews the applicant's airworthiness management system. For high-risk systems, the CAAC conducts compliance work in a greater number of areas. For medium-risk systems, the applicant conducts more compliance work by itself, with less CAAC intervention.<sup>14</sup> One example of the differences in risk level procedures is that applications for design and production approval are valid for one year for low-risk systems, whereas for other risk levels, the applications are valid for three years.<sup>15</sup> The

longer approvals for higher-risk systems likely represent the recognition of higher and longer-term investment expectations for larger, higher-risk drone systems.

The management system risk element, which is based on a subjective point system, is particularly important. The subjectivity potentially gives the CAAC more leeway in determining whether a potential commercial operator is lower or higher risk. For example, personnel competency, the second scoring criterion under the personnel category, is scored in a binary manner, with five points awarded for competency and zero points for a lack of competency. Unlike product risk, where guidelines mostly objectively lay out risk scoring, there are few objective guidelines for scoring management system risk. There are no objective measure guidelines instructing how to assess whether a potential operator's personnel could competently carry out responsibilities (能胜任承担的职责).

Additional areas in which the CAAC could potentially subjectively affect the risk score for a company include evaluations of organizational structure and management, facility adequacy, and internal auditing processes (see table A1). Point totals in subjective scoring categories can push an application from low to high risk, and vice versa.<sup>16</sup> Given the general risk assessment's heavy weighting of management system risk, subjective scoring could heavily influence the risk level of a potential operator.

This subjective scoring of commercial companies' management competence gives the CAAC greater intervention in the certification processes of applicants. Though it would be hard to prove, the CAAC may also intend to use this method to limit foreign drone operators crowding out China's fledgling domestic champions.

#### **Airworthiness Certification of Medium and Large Civil Unmanned Aerial Vehicles**

On October 29, 2021, the CAAC released drafts of airworthiness certification, registration, and safety analysis requirements for medium and large civil UAVs.<sup>17</sup> Medium UAVs weigh between 25 kilograms and 150 kilograms, and large UAVs exceed 150 kilograms in weight. These requirements cover design approval, engineering and manufacturing compliance, risk assessment, and detailed instructions and application forms for airworthiness certification applications.<sup>18</sup> Production licensing for limited-use UAVs still follows requirements released in 2019 for smaller aircraft.<sup>19</sup> Unlike the new airworthiness certification requirements, the registration and safety analysis requirements extend beyond medium and large civil UAVs to small UAVs.

#### **Registration Requirements**

The CAAC also released a draft guidance, including draft application forms, for unmanned aircraft system registration.<sup>20</sup> The requirement involves the registration of the UAV owner for real-name and nationality registration marks, consisting of QR codes applied to the surface of the UAV. Registration is available for Chinese and foreign nationals.

### **Safety Analysis Requirement Guide**

The safety analysis guide instructs applicants on classifying operational risks.<sup>21</sup> The document divides risk classification between cargo and passenger UAVs, implying that the CAAC anticipates passenger unmanned aircraft systems. The number of passengers, ranging from 1 to over 19, determines risk categories for passenger UAVs.

### **Technical Guidelines**

In addition to airworthiness certification regulations, the CAAC has also run trials on multiple technical guidelines for drone and UAV manufacturers. The following sections summarize key findings from a few CAAC regulations governing different risk and weight classes.

#### **Small Drones**

Because traditional surveillance and control systems are impractical for small drones, the CAAC has run trials of regulations requiring identification codes to be linked to real-name registration information. Mainland China—and now both Special Administrative Regions—has a similar policy for internet and cellular services.<sup>22</sup> The regulations also prohibit the use of automatic dependence surveillance-broadcast devices (transmitters often used on piloted aircraft) to broadcast their location for safety. Instead, the CAAC allows tracking information to be transmitted using other wireless technologies, including China's vast 4G and 5G cellular networks, to an integrated civilian unmanned aircraft management system.<sup>23</sup> Because small drones usually fly at low altitudes, transmitting data through cellular networks is technically feasible. Cellular transmission also allows Chinese officials to take advantage of the country's strength in 5G technology and ability to manufacture equipment domestically.

#### **Medium- to High-Risk Unmanned Helicopters**

The CAAC conducted trials on a set of specifications for medium- to high-risk unmanned helicopters. The unmanned helicopter manufacturing and business services sectors are fairly mature in China, and the draft requirements aim to satisfy a perceived gap in unmanned helicopter airworthiness standards.<sup>24</sup> In these guidelines, the CAAC highlights different weight and power requirements,<sup>25</sup> including requirements to reduce operating risk in civilian environments.<sup>26</sup> These highly technical requirements, which are tailored specifically to unmanned helicopter use, indicate that the CAAC is maturing its regulations away from broad decrees to specific guidelines that unmanned helicopter manufacturers and operators can follow.

### **High-Risk Fixed-Wing Cargo Drone Systems**

The CAAC's technical regulations for high-risk fixed-wing cargo drones are perhaps its most robust. The trial standards, which came into effect in January 2020, govern a wide range of technical factors, from takeoff speed and climb rate to runway conditions.<sup>27</sup> The robustness of technical standards for fixed-wing cargo drones may indicate that national regulators view this drone type as more economically viable in China than direct-to-consumer delivery drones. Courier companies such as SF Express have been pioneering large fixed-wing drones for cargo use. Unlike the other trial standards detailed in this policy brief, these trial standards have no end date, indicating that they may be very similar to those found in a final version.<sup>28</sup>

### **Urban Low-Altitude Logistics Drones**

The CAAC has released draft specifications for urban delivery route planning.<sup>29</sup> This move likely preempts the rollout of drone delivery services in dense urban areas. The draft, which is in an open-comment phase that started in July 2021, applies to small and light multirotor logistics UAVs operating at low altitudes in cities. The document stipulates risk assessments, including proximity to buildings and infrastructure, in a multistep procedure to calculate drone routes. The document also includes a route confidence score, which is based on safety, operational capabilities, and public acceptance, specifically regarding noise and privacy. The evaluation of operational capabilities, including drone communication methods, indicates that Chinese operators likely have the technological maturity to perform logistics deliveries in dense urban environments.

### **Drone Controller Licenses**

On December 23, 2021, the CAAC released draft regulations for licensing UAV controllers.<sup>30</sup> There are three types of licenses for UAV controllers: small drone controller licenses, medium-sized drone controller licenses, and large drone controller licenses.<sup>31</sup> The licenses are endorsed by the category level of a UAV and level's grade. Category levels include rotorcraft and VTOL aircraft, and grades include multi-rotor, autogyro, and helicopter classifications. The level of detail for licensing drone controllers indicates that the CAAC is preparing for the popularization of civilian UAV use, especially for commercial purposes.

### **Drone Sandboxes**

To test procedures and drone technology, the CAAC has established 13 drone sandboxes—regulator-designated areas and 3D areas of airspace for the testing of drones—across mainland China in a variety of geographical locations to test drone systems in as many conditions as possible.<sup>32</sup> The drone sandboxes (test areas) also can support the research of UAV safety and reliability, along with system compliance verification.<sup>33</sup> According to *China Aviation News*, the CAAC intends to use these drone sandboxes to test for safety, airspace use, and reliability of drone systems.<sup>34</sup> Notably, in June

2021, the Northwest Regional Administration of the CAAC initiated the construction of 5G towers, likely intended as a means of communicating with drones, testing UAV operations, and supporting infrastructure.<sup>35</sup> The CAAC encourages local governments near the drone sandboxes to tailor procedures to fit local environments and needs within the bounds of unified, national standards. Chinese local governments have less power to influence the overall development of drones and drone regulations than do states in the United States.<sup>36</sup> Our interpretations and analysis suggest that there will be little deviation between different local jurisdictions in China, allowing for a more uniform application of national policy.

## **STATE OF TECHNOLOGY AND COMMERCIAL ENVIRONMENT IN CHINA**

Several Chinese courier services, including SF Express and JD.com, have completed trials or have already started limited services. Last-mile courier flights are generally considered impractical in China's dense urban environments, so companies like SF Express are focusing on longer-distance fixed-wing drone cargo flights. China's industrial capacity allows for domestic manufacturing of most drone components. However, because many Chinese drone manufacturers rely on imported semiconductors, China's semiconductor bottleneck is an issue affecting drone manufacturing and many other Chinese manufacturing sectors.<sup>37</sup> China's advantage in battery technology, which aids the national electric vehicle market,<sup>38</sup> also promotes the manufacturing of electric-powered drones. The following sections examine a few examples of Chinese drone use gathered from English- and Chinese-language sources.

### **Fixed-Wing Cargo Drones**

Despite the commercial impracticality of last-mile delivery in China's dense urban environments, large fixed-wing cargo drones using airports have taken hold. SF Express, one of China's largest courier services, started conducting trials on large fixed-wing drones for cargo delivery between airports in August 2020. According to a press release, these plane-sized drones, such as the FH-98, retain the speed advantage of piloted aircraft with the cost efficiencies of semitrucks.<sup>39</sup> As demonstrated in its initial trial, the FH-98, with a range of around 1,200 kilometers, also can fly over rough, mountainous terrain less suitable for overland transport.<sup>40</sup>

Another company, Autoflight Aviation Technology Co., Ltd., unveiled the V400 Albatross, a drone with a 100-kilogram payload and a range of 300 to 1,000 kilometers at the Fourth Drone World Congress in Shenzhen in September 2020. Autoflight is targeting commercial customers in medical, mining, and infrastructure environments. Autoflight claims warehouse-to-warehouse cost efficiency can be reduced to below that of semitrucks in mountainous and island environments.<sup>41</sup> E-commerce giant JD.com has also developed its own fixed-wing cargo drones. Its 1-ton drone has a range of 1,000 kilometers, but the company intends to develop a 60-ton drone with a range of 6,000 kilometers. For context, these specifications outclass those of current narrow-body piloted freight aircraft.<sup>42</sup>

## Vertical Takeoff and Landing Cargo Drones

Chinese courier and e-commerce companies have been looking into vertical takeoff and landing (VTOL) drones for last-mile and rural deliveries. Whereas the urban east is mostly developed, China's mountainous interior lacks infrastructure, and thus Chinese courier and e-commerce companies are investing in VTOL cargo drones for lightly populated regions. Large VTOL cargo drones can enable SF Express to reach China's large rural population—40 percent of its total population. Cargo drones may be an area where China specializes because these large drones may not be commercially practical in the United States, where the rural population only accounts for 17 percent of the total population.<sup>43</sup>

Several companies are testing VTOL cargo drones. In October 2019, the CAAC issued the first UAV Logistics Distribution Business License (无人机物流配送经营许可) on a trial basis to a subsidiary of Antwork, an urban air distribution company backed by venture capitalists including the Sequoia Capital China Fund.<sup>44</sup> SF Express also delivered medical supplies in Wuhan with a smaller VTOL cargo drone in a much-publicized transportation mission when the spread of COVID-19 locked down the city in early 2020.<sup>45</sup> SF Express intends to buy large VTOL cargo drones from Slovenian aerospace firm Pipistrel for cargo delivery to rural China. JD.com has also invested in and used similar VTOL drone systems.<sup>46</sup>

## Passenger Drones

EHang is a prominent passenger drone company in China. The company has completed several test flights of its autonomous one- and two-passenger eVTOL aircraft worldwide and has partnerships in Europe and the United States. In April 2019, EHang's cofounder said the company was already completing routine flights in China for tourists between a hotel and local attractions.<sup>47</sup> By August 2019, EHang had completed more than 2,000 test flights of its autonomous eVTOL aircraft in China and abroad, and the company announced a partnership with the city of Guangzhou to build infrastructure and systems for its air taxi service.<sup>48</sup> That month, EHang announced it would be flying passengers on three or four eVTOL routes in Guangzhou as part of a pilot program approved by the CAAC.<sup>49</sup> According to EHang financial reports, the company delivered 60 of its autonomous two-passenger eVTOL aircraft to customers in 2019.<sup>50</sup> The company hopes to deliver 250 of its autonomous two-passenger aircraft in 2021 and, as of this writing, is setting up 30 to 40 eVTOL routes in China.<sup>51</sup> These eVTOL flight corridors are fixed aerial highways, typically 50 to 200 meters above the ground.

## US NATIONAL POLICIES AND REGULATIONS

The United States has a large and well-funded technology and aerospace sector, and in 2012 and 2016 Congress expressly instructed the FAA to prioritize the commercialization of drone services.<sup>52</sup> As explained later, US drone policies are in part a reaction to the real and perceived successes



of Chinese companies in small drone manufacturing. In 2018, Congress passed and the president signed a drone law requiring transportation officials to “use a risk-based approach”—as opposed to approaches based on weight or propulsion—in permitting drone operations,<sup>53</sup> although weight features prominently in regulators’ assessment of risk.<sup>54</sup>

In practice, lightweight drones have novel requirements for operation, whereas large drones are often regulated similarly to—and classified as—traditional aircraft of similar size. Another distinguishing characteristic of US policy is the significant role that states and tribes (as sovereign subnational units) play in developing drone law and policy. The role of states and tribes means a somewhat fragmented regulatory environment, especially for small drone operations, but this environment has allowed for more policy entrepreneurship and commercial experimentation in regions and cities across the country.

### Small Drones

The United States has a federal system of government and strong constitutional protections for property rights, which means national regulations and policy are shaped in collaboration with state, tribal, and local authorities. There is substantial legal uncertainty about federal-state power sharing. This uncertainty in turn creates an uncertain investment climate as operators seek to progress from pilot programs to commercial rollout. As the Government Accountability Office (GAO) reported in September 2020, federal and state governments haven’t formalized their roles over drone operations,<sup>55</sup> and previous attempts have faltered.

For instance, in early 2017 the FAA charged a task force of industry members and state and local officials to recommend ways federal and state lawmakers could share authority over drone operations. That effort failed in late 2017, only months after formation, and the acrimonious collapse of discussions in the task force was reported by the *Washington Post* on October 23, 2017.<sup>56</sup> Two days later, a presidential memorandum created the three-year drone Integration Pilot Program (IPP), overseen by the US Department of Transportation (DOT), to experiment with regulatory regimes for drone management, with hopes of identifying what should be devolved to states and cities and what should be the federal government’s role.<sup>57</sup> As part of the IPP, the DOT (and its subagency the FAA) selected 10 participants—state, local, and tribal agencies—from 149 applicants.<sup>58</sup> That three-year program concluded in the fall of 2020, and in its place the FAA created the BEYOND program. To date, the IPP hasn’t led to any formal position about how federal and state authorities will share authority over drone airspace (400 feet and lower above the ground) and operations.

With the BEYOND program, the FAA extended agreements with 8 of the 10 IPP participating agencies. Whereas the IPP’s focus was to begin formalizing federal-state sharing of regulatory responsibilities, the BEYOND program drone operations focus on (a) analyzing routine and economically viable long-distance drone operations, (b) analyzing and quantifying the economic

and social benefits of drones, and (c) analyzing and addressing the public’s concerns about drone operations. As of this writing, these initiatives are at an early stage, and there is little publicly reported about their progress.

Separate and apart from the IPP and BEYOND initiatives are the commercial programs that are popping up nationwide. The ad hoc and informal nature of drone operations rules means that long-distance drone operations are often permitted case by case and through an FAA regulatory waiver. We’re unaware of any source compiling all the FAA-compliant long-distance operations, but there appear to be dozens of commercial pilot programs.<sup>59</sup> Our research and analysis indicate that these commercial test programs typically arise when a drone operator, with a federal waiver in hand to do complex operations, approaches and seeks permission from local leaders to test commercial drone services in that town or city.

### Large Drones

Less information has been publicly reported in the United States about large drones—passenger drones and freight drones—but companies have been testing large electric drones in the United States for several years.<sup>60</sup> FAA Administrator Steve Dickson, at a May 2021 hearing of the House Committee on Appropriations, noted that the FAA was working with several passenger drone companies and that he anticipated some to be certified in 2023 and operations to begin as early as 2024.<sup>61</sup> Rather than create a separate regulatory classification for passenger drones, as European regulators did in 2021,<sup>62</sup> the FAA seems to be encouraging most passenger drone companies in the United States to use an existing classification, Part 23. This longstanding classification for small planes was updated in 2017 to be more flexible than traditional aircraft certifications. However, although flexible, according to the GAO this Part 23 classification is underused by federal regulators and viewed as incompletely defined by the industry.<sup>63</sup>

Nevertheless, the technology looked promising enough that in late 2019, the US Air Force began a program, called Agility Prime, to accelerate domestic eVTOL (and hybrid VTOL) development.<sup>64</sup> The Pentagon plans to spend about \$100 million annually on eVTOL and large drone development.<sup>65</sup> The Agility Prime program grants large drone companies access to both financial assistance and military facilities and airspace to test passenger and freight drone services.<sup>66</sup>

To participate, companies must complete a series of challenges, such as carrying a payload a certain distance at a certain speed.<sup>67</sup> Whereas the initial goal of the Agility Prime program was to find useful military applications for large drones, such as medical evacuation and freight delivery, an express goal of program leaders—perhaps the dominant goal—is to give US eVTOL manufacturers a head start in the global race to develop a domestic industry in commercial large drone manufacturing and services.<sup>68</sup> Air Force officials note that their intent with the military program jump-starting commercial eVTOL supply chains in the United States is to avoid what happened

a decade earlier with small drone supply chains, which moved mostly to China, an economic and geopolitical rival.<sup>69</sup>

By granting funds and military airspace use to US companies, program leaders hope that companies will gain certification for military use and stimulate commercial investment into the sector for dual use—military *and* commercial services. Although not as rigorous as FAA certification of aircraft, military certification of new aircraft gives a company credibility with investors and suppliers and can likely be granted more quickly than FAA certification.

It's unclear to us whether and to what extent the military agencies and the civilian agencies (the National Aeronautics and Space Administration [NASA] and the FAA) are collaborating, but concurrently with Agility Prime, in the fall of 2019 NASA announced a multiyear Urban Air Mobility Grand Challenge,<sup>70</sup> reminiscent of the government's Defense Advanced Research Projects Agency's autonomous vehicle Grand Challenge, a prize competition that began in 2004 and helped jump-start the commercial autonomous vehicle market.<sup>71</sup> Among other things, NASA is providing commercial participants access to its premier aviation research center, the Neil A. Armstrong Flight Research Center at Edwards Air Force Base in California, and to government airspace to test eVTOL aircraft.<sup>72</sup> At the time of this writing, NASA is soliciting participation from eVTOL companies to begin test operations at various locations across the nation.<sup>73</sup> Those test operations are planned for summer 2022 through at least 2024.<sup>74</sup>

Joby Aviation appears to be furthest along in its interactions with the US Air Force and with the commercial certification process. In August 2021, the company became the first US-based eVTOL company to go public, and company representatives expect their aircraft to be FAA certified and ready for operations in 2024.<sup>75</sup> Joby's five-seat eVTOL aircraft has a range of 150 miles and a cruising speed of more than 200 mph.<sup>76</sup> We're unaware of any commercial purchases completed for freight or passenger drones in the United States, although some companies have pledged future orders.<sup>77</sup>

The United States is not as far along in setting up eVTOL and UAM routes as Chinese regulators and industry. However, in June 2020, NASA and the FAA announced plans to create corridors for UAM providers.<sup>78</sup> In early 2021, the federal agencies signed agreements with five state and local jurisdictions to study UAM services.<sup>79</sup> This step appears to be the first toward operations in those jurisdictions, but it's unclear as of this writing when the studies will conclude, the corridors will be designated, and the large drone operations will commence.

## **COMPARISON AND POLICY RECOMMENDATIONS FOR US LAWMAKERS**

Whereas China has a head start in commercial drone manufacturing and large drone operations, the subjectivity in its rules and production approval and airworthiness certification processes, which seem intended to preserve discretion for the CAAC and other relevant authorities to

greenlight favored drone operators, may hinder or distort commercial investment. As discussed in a previous section, categorizing a drone system as lower risk essentially allows the CAAC to expedite approval by allowing the applicant to conduct more of the compliance checks than in situations where the drone system is classified as medium or high risk. This heavy-handedness in guiding the industry and crowning national champions could backfire if regulatory politics were to interfere with commercial development.

If the United States develops regulations with the specificity of the CAAC's recent trial standards and draft regulations, more objective standards in any FAA airworthiness certification process may encourage more potential drone operators to apply, creating more competition in the drone market. The United States, with many single-family homes, has an advantage in last-mile drone deliveries because China's urban environment dominated by apartment buildings makes direct-to-consumer last-mile deliveries by drone much more challenging. As for drone data links, China may have an advantage in its developed 5G network for micro and lightweight drone communications. China's rugged terrain and large rural population are also less suitable for overland transportation, making commercial drone development a government priority in reducing logistical costs.

Whether the various US government plans, programs, and funds for small and large drones amount to industrial policy we leave to others to debate. The United States is certainly not doing the hand-picking of national champions seen in China, South Korea, and Japan in technology and manufacturing fields, but it's not a laissez-faire approach either. We are concerned, for instance, that regulators will create standards and federal advisory groups that are facially neutral but whose underlying intent or effect is to benefit favored firms. There are hundreds of drone manufacturers and service providers seeking to succeed in the United States, and regulators will be under immense pressure to winnow the commercial field—each provider clamoring for high-value drone routes—through regulation.

The soft promotion of US national champions by regulation, binding standards, and regulators' selective reliance on powerful commercial companies could result in a politicized industrial policy. Although some analysts favor strong government guidance of nascent industries, the optimistic literature about industrial policy suffers from a problem of survivorship bias—success stories get told, but the many costly failures of government support of industries are rarely examined and quickly forgotten.<sup>80</sup> We conclude with some policy recommendations.

#### Lease or Auction New Aviation Corridors

It's clear that there is a race to serve and claim high-revenue drone corridors. To avoid other types of administrative rationing of UAM and drone routes—such as first-come, first-served and vague standards that preserve regulator discretion and drive out less-favored competitors—regulators

should create a market for airspace. This could take the form of auction or leasing of routes or geographic delivery zones. The GAO and Airbus have discussed this approach, among others.<sup>81</sup>

FAA officials “expect the first examples of [eVTOL aircraft for] routine taxi service between city rooftops to be certified within two years.”<sup>82</sup> Furthermore, those aircraft will “operate along set routes that will be ‘more segregated than integrated.’” Demand modeling indicates that central-business-district-to-airport routes will be the most attractive to UAM providers.<sup>83</sup> In Los Angeles, for instance, “LAX to downtown L.A., Anaheim, Hollywood, and Long Beach were identified as the top four UAM corridors in order.”<sup>84</sup>

The US government’s current tentative plans are to delegate route rationing and traffic management to trusted (currently undetermined) members of industry.<sup>85</sup> The potential for a few firms to “route squat” on high-revenue air taxi routes and to exclude future competitors is massive and foreseeable. McKinsey analysts reported in early 2019, for instance, on the anticompetition problem: “[F]irst movers will have an advantage by securing the most attractive sites along high-traffic routes.”<sup>86</sup> There is a similar risk in drone parcel delivery. At low altitudes drone operators are likely going to be limited to the air above public rights-of-way and public easements to avoid lawsuits from private landowners.<sup>87</sup> Regulators need to anticipate and prevent the politicized rationing of routes by regulation.

#### Formalize Federal and State Authority over Surface Airspace

Given the realities of drone operations and their impact on local trespass, nuisance, privacy, and takings laws, a formal recognition of state authority below, say, 200 feet and federal authority above 200 feet would create a more predictable legal environment for operators, landowners, and state governments.<sup>88</sup> A GAO report to Congress in the fall of 2020 reported that the DOT and US the Department of Justice had created a joint task force to formalize the federal government’s position about federal-state sharing of drone authority.<sup>89</sup> That task force is expected to release its findings soon, but as of this writing, that government position has not been released.

The federal government and state governments need to know which low-altitude airspace and drone operations are under local jurisdiction and which are under federal jurisdiction. Several academic articles and a few federal bills have recognized the problem and propose drawing lines. For example, a boundary 200 feet above the ground would recognize the property and privacy expectations of landowners while also allowing a higher-altitude easement for drone commerce.<sup>90</sup>

## Expand Sandboxes for Drone Companies

The practice of opening military and public aviation facilities and airspace to new eVTOL and drone companies is an inexpensive and light-handed way to encourage commercial innovation and iteration with new aircraft.<sup>91</sup> Federal and state officials should open more drone sandboxes where entrepreneurs can test their new aircraft and services and show investors progress and proof of concept. Several countries have established drone sandboxes. Spanish regulators and the Barcelona Drone Center, for instance, have opened a 50-square-kilometer area of airspace for companies to test drones and passenger drones.<sup>92</sup> There are few dedicated sandboxes like that in the United States, and state departments of transportation and the DOT should promote drone sandboxes for small drones and passenger drones. Similar to what the CAAC allows Chinese local governments to do with drone sandboxes, state departments of transportation should also be able to tailor drone sandbox environments and procedures to regional geographies and needs.

## CONCLUSION

Whereas China has a head start with the large-scale implementation of commercial drones for logistics, the United States can likely lead in a direct-to-consumer drone services market, given residential patterns and relatively high incomes in the country. China's top-down government, uniform national policy, and manufacturing advantages have produced viable commercial platforms like SF Express's fixed-wing cargo delivery drone systems and a plethora of manufacturers. However, the US government also has advantages and should play to these strengths: regulatory transparency, state governments serving as independent sources of authority and of permission granting, market disposition of public assets, and a tolerance for competition.

As stated in our recommendations, the United States should create a market for airspace and foster competition. Making aerial corridors transferable assets would allow corridors to generally go to their highest-valued use, as seen in federal spectrum and offshore energy auctions and leases, and would allow newcomers a way to enter a saturated drone services market. The ability for states and local governments to tailor regulations to local environments also gives the United States greater regulatory flexibility to better suit the needs of local markets. By playing to its strengths in regulatory transparency and shared power between the federal, state, and local governments, US-based companies can test quickly and thrive in a globally competitive drone services market.

## APPENDIX

**Table A1. Applicant’s Management System Risk Element Score Sheet (Translated)**

ELEMENT		POINTS
Organization	Whether there is a proper organizational structure and management, and whether the responsibilities and authorities of each department are clear. (Yes: 5 points. No: 0 points)	
	Whether there is a department that can undertake airworthiness management functions. (Yes: 6 points. No: 0 points)	
Personnel	Are there enough experienced professionals? (Yes: 5 points. No: 0 points)	
	Whether the personnel are competent for the duties they undertake. (Yes: 5 points. No: 0 points)	
	Familiarity with the airworthiness requirements of drones. (Familiar: 6 points. Normal: 3 points. Unfamiliar: 0 points)	
	Whether professional technicians and airworthiness management personnel have received relevant training. (Yes: 5 points. No: 0 points)	
Facilities and equipment	Whether there is a fixed space for design, production, verification, and display of compliance with procedures. (Yes: 3 points. No: 0 points)	
	Are there test equipment and facilities for design, production, verification, and demonstration of compliance? (Yes: 3 points. No: 0 points)	
	Are there record-keeping facilities? (Yes: 3 points. No: 0 points)	
Process control	Is there a system of clarifying the role for each process? (Yes: 5 points. No: 0 points)	
	Is the process control set according to the different characteristics of design, production, and airworthiness verification? (Yes: 5 points. No: 0 points)	
	Is there process control related to design, design changes, compliance certification, supplier control, continuous airworthiness, etc.? (Yes: 5 points. No: 0 points)	
	Is there process control of production-related processes such as design data control, design and production coordination, manufacturing process, inspection and test process, product control, supplier control, predelivery maintenance, continuous airworthiness, etc.? (Yes: 5 points. No: 0 points)	
Document control	Are there document management capabilities? (Yes: 5 points. No: 0 points)	
	Is there a document describing the CUAV system (usually an airworthiness management system manual)? (Yes: 6 points. No: 0 points)	
	Are project records, design or change materials, compliance verification materials and compliance verification work documents complete? (Yes: 5 points. No: 0 points)	
	Are there complete documents related to the work scope of authorized personnel? (Yes: 3 points. No: 0 points)	
Internal audit/CAAC audit	Are there reasonable processes to ensure the control and implementation of internal review and corrective measures? (Yes: 5 points. No: 0 points)	
	Does the above mechanism include necessary management methods such as incident records, risk identification, mitigation measures, performance indicators, etc.? (Yes: 5 points. No: 0 points)	
	Implementation of corrective measures. (Good: 5 points. Fair: 3 points. None: 0 points)	
	Is there a satisfactory reporting mechanism to the CAAC? (Yes: 5 points. No: 0 points)	
Total score		

Source: Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wu ren ji xitong shi hang shending xiangmu fengxian pinggu zhinan (shixing)” 民用无人机系统适航审定项目风险评估指南 (试行) [Civilian unmanned aircraft airworthiness certification project risk assessment guidance (trial)], May 26, 2020.

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## NOTES

1. Of the top 10 tech companies by market cap, 6 are based in the United States, 2 are based in China, and 1 is based in Taiwan. "Largest Tech Companies by Market Cap," CompaniesMarketCap.com, accessed September 8, 2021, <https://companiesmarketcap.com/tech/largest-tech-companies-by-market-cap/>.
2. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), *Jiyu yuxing fengxian de wu ren ji shi shending zhidao yijian* 基于运行风险的无人机适航审定指导意见 [Guidance on UAV airworthiness certification based on operational risk], January 25, 2019, [http://www.caac.gov.cn/PHONE/XXGK\\_17/XXGK/ZFGW/201901/P020190125609946283900.pdf](http://www.caac.gov.cn/PHONE/XXGK_17/XXGK/ZFGW/201901/P020190125609946283900.pdf). All references to drones in this publication are for civilian and commercial drones.
3. "Notice of the Consultation on the Guidance for the Development of Civil Unmanned Aerial Vehicles (Draft for Comments)," Civil Aviation Administration of China, May 14, 2019, [http://www.caac.gov.cn/PHONE/HDJL/YJZJ/201905/t20190514\\_196175.html](http://www.caac.gov.cn/PHONE/HDJL/YJZJ/201905/t20190514_196175.html).
4. "UAS by the Numbers," Federal Aviation Administration, last modified September 8, 2021, [https://www.faa.gov/uas/resources/by\\_the\\_numbers/](https://www.faa.gov/uas/resources/by_the_numbers/).
5. See, for example, Federal Aviation Administration, *Concept of Operations Version 2.0: Unmanned Aircraft Systems (UAS) Traffic Management (UTM)*, n.d.; Deloitte Consulting LLP and National Aeronautics and Space Administration, *UAM Vision Concept of Operations (ConOps) UAM Maturity Level (UML) 4 Version 1.0*, n.d.
6. Operation of Small Unmanned Aircraft Systems Over People, 86 Fed. Reg. 4314 (January 15, 2021); Remote Identification of Unmanned Aircraft, 86 Fed. Reg. 4390 (January 15, 2021).
7. The term "sandbox," in technology policy, refers to a designated place, either geographical or digital, where new technologies can be tested under liberal rules for a predetermined duration. The policy goal is to stimulate a new industry or service such that innovators and regulators can watch and learn about the new technology without a full-scale launch to the public. Molly Leshner, "Bringing New Digitally Enabled Products and Services to Market: Sandboxes and the Role of Policy Experimentation," *VoxEU*, Centre for Policy Research, October 13, 2020.
8. Brent Skorup and Will Gu, "A Look at Industrial Policy for Drones and eVTOL in China," *Technology Liberation Front*, July 26, 2019.
9. "CAAC Issued Management Procedures for Trial Operation of Specific Types of UAS (Interim)," Civil Aviation Administration of China, March 5, 2019, <https://perma.cc/6U4Q-J48J>.



10. National champions “are companies which help further the government’s strategic aims and in return, the government supports these companies by providing easier access to financing, giving preference in government contract bidding, and sometimes oligarchy or monopoly status in protected industries, giving these companies a number of advantages over their competitors.” Antonio Graceffo, “China’s National Champions: State Support Makes Chinese Companies Dominant,” *Foreign Policy Journal*, May 15, 2017.
11. “Notice on the Issuance of the Regulations for the Review and Administration of Airworthiness of Civil Drone Products (Trial) and the Guidelines for Risk Assessment of Airworthiness Validation Projects for Civil Drone Systems (Trial),” Civil Aviation Administration of China, Airworthiness Audit Division, May 26, 2020, <https://perma.cc/PHT3-DR5M>.
12. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), *Minyong wu ren hang ji chanpin shi hang shending guanli chengxu (shixing) 民用无人机产品适航审定管理程序 (试行)* [Civilian unmanned aircraft airworthiness certification management program (trial)], May 26, 2020.
13. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), *Minyong wu ren ji xitong shi hang shending xiangmu fengxian pinggu zhinan (shixing) 民用无人机系统适航审定项目风险评估指南 (试行)* [Civilian unmanned aircraft airworthiness certification project risk assessment guidance (trial)], May 26, 2020.
14. The CAAC lists additional areas in which the CAAC inspects in the application.
15. If the applicant cannot obtain a design and production approval letter within the validity period, it can obtain an extension of the application validity period.
16. Of the 100 total points for system management risk, in a system where a score at or above 70 earns the potential operator a low management system risk level, at least 41 points can be subjectively scored. (See table A1. Categories in red text indicate criteria with possible subjective scoring.)
17. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Guanyu jiu ‘minyong wu ren jiashi hangkongqi xitong shi hang shending guanli chengxu’ deng san fen xingzheng guifan xing wenjian zhengqiu yijian de tongzhi” 关于就《民用无人驾驶航空器系统适航审定管理程序》等三份行政规范性文件征求意见的通知 [Notice soliciting opinions on three administrative standard documents on “management of civil unmanned aircraft system airworthiness certification procedures”], October 29, 2021, <https://perma.cc/ZG8C-SDNJ>.
18. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wu ren jiashi hangkongqi xitong shi hang shending guanli chengxu (zhenqiu yijian gao)” 民用无人驾驶航空器系统适航审定管理程序 (征求意见稿) [Management of civil unmanned aircraft system airworthiness certification procedures (draft for comment)], October 29, 2021, <https://perma.cc/LT8N-RHMH>.
19. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Qing xiaoxing hangkongqi shengchan xuke ji shi hang pizhun shending chengxu” 轻小型航空器生产许可及适航批准审定程序 [Approval procedures for production licenses and airworthiness of small and light aircraft], October 31, 2019, <https://perma.cc/Q8J4-KP3X>.
20. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wu ren jiashi hangkongqi dengji guanli chengxu (zhengqiu yijian gao)” 民用无人驾驶航空器登记管理程序 (征求意见稿) [Management of civil unmanned aircraft registration procedures (draft for comment)], October 29, 2021, <https://perma.cc/4PFC-STUR>.
21. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wu ren jiashi hangkongqi xitong anquan xing fenxi zhinan (zhengqiu yijian gao)” 民用无人驾驶航空器系统安全性分析指南 (征求意见稿) [Civilian unmanned aircraft system safety analysis guide (draft for comment)], October 29, 2021, <https://perma.cc/35F7-4958>.
22. Josh Chin, “China Is Requiring People to Register Real Names for Some Internet Services,” *Wall Street Journal*, February 4, 2015.
23. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wei qing xiaoxing wu ren jiashi hangkongqi yunxing shibie gainian ji yaoqiu (zhanxing)” 民用微轻小型无人驾驶航空器运行识别概念及要求 (暂行) (Provisional concepts and requirements for civilian micro and lightweight unmanned aircraft operation), March 8, 2021, <https://perma.cc/E4ZU-4K6F>.

24. “Notice of Comments on the Airworthiness Standards for Medium- and High-Risk Unmanned Helicopter Systems (Trial),” Civil Aviation Administration of China, <https://perma.cc/J6MU-93TC>.
25. Autorotation refers to a state of flight where moving air, rather than a motor, turns the main rotor(s), allowing a helicopter to safely land in case of engine failure.
26. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Zhonggao fengxian wu ren zhishengji xitong shi hang biao zhun (shixing)” 中高风险无人直升机系统适航标准 (试行) (Medium-High Risk Unmanned Helicopter System Airworthiness Standards [Trial]), May 11, 2021, <https://perma.cc/89F6-EUGA>.
27. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Guanyu fabu gao fengxian huoyun guding yi wu ren ji xitong shi hang biao zhun (shixing) de tongzhi” 关于发布高风险货运固定翼无人机系统适航标准 (试行) 的通知 [Notice on newly issued high-risk fixed-wing cargo UAV airworthiness standards (draft)], January 20, 2020, <https://perma.cc/6LV6-ZMTA>.
28. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Gao fengxian huoyun guding yi wu ren ji xitong shi hang biao zhun (shixing)” 高风险货运固定翼无人机系统适航标准 (试行) [High-risk fixed-wing cargo UAV airworthiness standards (draft)], January 20, 2020, <https://perma.cc/6GAF-XEXB>.
29. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China) “Chengshi dikong wu ren jiashi hangkong wuliu hangxian hua she guifan” 城市低空无人驾驶航空物流航线划设规范 [Specification of urban delivery route planning of unmanned aircraft systems], July 14, 2021, <https://perma.cc/G45M-8UP2>.
30. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Guanyu dui ‘minyong wu ren jiashi hangkongqi caokong yuan guanli guiding’ zixun tonggao zhengqiu yijian de tongzhi” 关于对《民用无人驾驶航空器操控员管理规定》咨询通告征求意见的通知 [Notice soliciting opinions for draft of regulations on “management of civil unmanned aircraft controllers”], December 23, 2021, <https://perma.cc/6HBW-HWYD>.
31. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minyong wu ren jiashi hangkongqi caokong yuan guanli guiding (zhengqiu yijian gao)” 民用无人驾驶航空器操控员管理规定 (征求意见稿) [Regulations on management of civil unmanned aircraft controllers (draft for comment)], December 23, 2021, <https://perma.cc/L4EE-VDT9>.
32. Zhongguo Minyong Hangkong Ju 中国民用航空局 (Civil Aviation Administration of China), “Minhang jj guanyu gongbu shou pi minyong wu ren jiashi hangkong shiyan jidi (shiyan qu) de tongzhi” 民航局关于公布首批民用无人驾驶航空试验基地 (试验区) 的通知 [Notice of the civil aviation authority on the publication of the first civil unmanned aerial test sites (test areas)], October 10, 2020, <https://perma.cc/97EP-TNR8>.
33. “CAAC Issues Measures for the Management of Unmanned Civil Aviation Experimental Bases (Test Areas),” Civil Aviation Administration of China, March 25, 2021, <https://perma.cc/4V3F-CSWE>.
34. “The Civil Aviation Authority Announced a Summary of the First 13 Civil Unmanned Aerial Test Sites,” *China Aviation News*, January 21, 2021, <http://www.cannews.com.cn/2021/01/21/99319322.html>.
35. “Xibei ju tuijin yulin minyong wu ren jiashi hangkong shiyan qu jianshe” 西北局推进榆林民用无人驾驶航空试验区建设 [Northwest administration promotes construction of Yulin civil unmanned aviation test zone], Zhongguo Minyong Hangkong Xibei Diqu Guanli Ju 中国民用航空西北管理局 (Civil Aviation Administration of China Northwest Regional Administration), June 22, 2020, <https://perma.cc/PG43-AZNZ>.
36. Brent Skorup and Connor Haaland, “Which States Are Prepared for the Drone Industry?” (Mercatus Research, Mercatus Center at George Mason University, Arlington, VA, January 14, 2021).
37. Lu Peishan 卢佩珊, *2020 nian zhongguo wuliu wu ren ji hangye gailan* 2020 年中国物流无人机行业概览 [Overview of China’s logistics drone industry in 2020], April 2020, [http://pg.jrj.com.cn/acc/Res/CN\\_RES/INDUS/2021/1/7/80e337ff-2722-4b94-a31d-aal9432dd75.pdf](http://pg.jrj.com.cn/acc/Res/CN_RES/INDUS/2021/1/7/80e337ff-2722-4b94-a31d-aal9432dd75.pdf).
38. McKinsey & Company, “Building Better Batteries: Insights on Chemistry and Design from China,” McKinsey & Company, April 22, 2021.

39. “Shunfeng Large-Scale Drones First Put into Operation Scene, Successfully Landed at Inner Mongolia Airport,” SF Express, August 21, 2020, <https://www.sf-express.com/cn/en/news/detail/-01497/>.
40. Chai Hua, “Larger Drones Take Skies by Storm,” *China Daily*, October 9, 2020.
41. Hua, “Larger Drones.”
42. Men Xianrui 孟宪瑞, “Jingdong wu ren yun huoji xia xian, weilai hai yao yanfa zaizhong 60 dun de danxing wu ren ji” 京东无人运货机下线,未来还要研发载重 60 吨的大型无人机 (JD’s unmanned freighter rolls off the assembly line, will develop large drone capable of carrying 60 tons in the future), *EXPreview*, n.d., <https://www.expreview.com/62171.html>.
43. World Bank Indicators, Rural Population (% of Total Population)—China, United States (database), accessed July 21, 2021, <https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=CN-US>.
44. Xu Yegang, “Xun Ant Delivery Bar Gets World’s First City Drone Test Run ‘License,’” *China Civil Aviation News*, October 15, 2019.
45. Song Jingli, “SF Express Completes First Drone Delivery to Hospital in Coronavirus-Hit Wuhan,” *KrASIA*, February 13, 2020.
46. “Wu ren ji kaudi ‘cong tian er jiang’ bu jing yao kuai geng yao ‘wen’” 无人机快递 “从天而降” 不仅要快更要 “稳” [Drone express “falling from the sky” not only fast but also “steady”], *Xinhuanet*, April 29, 2020.
47. Chen Chuanren, “China Abuzz with eVTOL Action,” *AINonline*, April 17, 2019.
48. “Guangzhou Chosen as Urban Air Mobility Pilot City,” *SmartCitiesWorld*, August 8, 2019.
49. Arjun Kharpal, “China Could Be the First in the World to Start Regular Flights on Pilotless Passenger Drones,” CNBC, August 28, 2019.
50. Charles Alcock, “Early eVTOL Deliveries Boost EHang’s Revenues in 2019,” *AINonline*, March 25, 2020.
51. Chris Stonor, “‘Exclusive Interview’ with Huazhi Hu, EHang Founder and CEO,” *Urban Air Mobility News*, May 6, 2021.
52. See, for example, FAA Modernization and Reform Act of 2012 (FMRA), Pub. L. No. 112-95, § 332, 126 Stat. 11 (2012); FAA Extension, Safety, and Security Act of 2016, Pub. L. No. 114-190, 130 Stat. 615 (2016).
53. Special Authority for Unmanned Systems, 49 U.S.C. § 44807.
54. That law sunsets in 2023.
55. Government Accountability Office, *Unmanned Aircraft Systems: Current Jurisdictional, Property, and Privacy Legal Issues Regarding the Commercial and Recreational Use of Drones*, September 16, 2020, <https://www.gao.gov/assets/b-330570.pdf>.
56. Michael Laris, “A U.S. Drone Advisory Group Has Been Meeting in Secret for Months. It Hasn’t Gone Well.,” *Washington Post*, October 23, 2017.
57. In 2017, the US secretary of transportation asked, “How much authority should local municipalities or county governments have over drone operations? And what about drones operating beyond the operator’s line of sight?” Elaine L. Chao, “Remarks Prepared for Delivery by U.S. Secretary of Transportation Elaine L. Chao” (Drone Focus Conference, Fargo, ND, May 31, 2017), <https://www.transportation.gov/briefing-room/drone-focus-conference>.
58. Federal Aviation Administration, “U.S. Transportation Secretary Elaine L. Chao Announces Successful Completion of Drone Pilot Program, Announces New Program Called BEYOND,” FAA news release, October 30, 2020, [https://www.faa.gov/news/press\\_releases/news\\_story.cfm?newsId=25420](https://www.faa.gov/news/press_releases/news_story.cfm?newsId=25420); “BEYOND,” March 16, 2021, [https://www.faa.gov/uas/programs\\_partnerships/beyond/](https://www.faa.gov/uas/programs_partnerships/beyond/).
59. See, for example, Meg Garner, “Fred Meyer Parent Kroger to Test Drone Deliveries,” *Portland Business Journal*, May 3, 2021; “Walmart Expands Its Delivery to Raeford,” news story by WNCN CBS 17, video, April 7, 2021, <https://www.youtube.com/watch?v=yAlYhB2qrAE>; Annette Beard and Serenah McKay, “Planners Approve Walmart Drone Launch Pad Request in Pea Ridge,” *Northwest Arkansas Democrat Gazette*, January 6, 2021; Oliver Mitchell, “Inside Oklahoma’s Burgeoning Drone Ecosystem,” *Robot Report*, November 3, 2020; “Walmart to Test Drone Delivery of COVID-19 Test Kits,” *Reuters*, September 22, 2020; Jake Bright, “Zipline Begins US Medical Delivery with Drone Program Honed in

- Africa,” *TechCrunch*, May 27, 2020; Miriam McNabb, “UPS Drone Delivery: DroneUp Flies to Prove the Case for Coronavirus Response,” *DroneLife*, April 21, 2020; Alex Chidbachian, “El Pollo Loco Partnering with Flytrex for Drone Delivery Service,” *KTTV Fox 11*, June 19, 2021.
60. For instance, in October 2019 Airbus representatives said that they had completed more than 100 fully autonomous eVTOL test flights in Oregon. Tom Banse, “Air Taxi by Airbus Completes 114 Test Flights in Northwest Skies,” *KUOW*, October 11, 2019.
  61. “Federal Aviation Administration Safety Oversight Hearing,” exchange between FAA Administrator Steve Dickson and Committee Chair Rep. Mario Diaz-Balart, House Committee on Appropriations, 1:42:00, May 12, 2021, [https://www.youtube.com/watch?v=UrVHy\\_9jKAE](https://www.youtube.com/watch?v=UrVHy_9jKAE). Dickson expressly mentions “advanced air mobility” companies, but this term overlaps substantially with passenger drone and eVTOL companies.
  62. European Union Aviation Safety Agency, “Special Condition for VTOL and Means of Compliance,” EASA document library, June 23, 2021, <https://www.easa.europa.eu/document-library/product-certification-consultations/special-condition-vtol>.
  63. Government Accountability Office, “Aviation Certification: FAA Needs to Strengthen Its Design Review Process for Small Airplanes” (report no. GAO-21-85, Government Accountability Office, Washington, DC, November 16, 2020).
  64. Brian Garrett-Glaser, “US Air Force Hopes to Leverage Commercial Progress on ‘Air Taxi’ Vehicles,” *Aviation Today*, October 30, 2019.
  65. Andy Pasztor and Andrew Tangel, “U.S. Air Force Gives Lift to Flying Taxis,” *Wall Street Journal*, December 10, 2020.
  66. “Air Force Evaluates Kitty Hawk’s Heavyside eVTOL for Medevac Missions,” *eVTOL*, June 8, 2021.
  67. Brian Garrett-Glaser, “Through Agility Prime, Air Force Commits to Commercial Success of Air Taxis,” *Aviation Today*, April 28, 2020.
  68. According to a *Wall Street Journal* article, “The long-term goal [of Air Force testing and certifying eVTOL aircraft] is for the military to collaborate with industry and the FAA to ensure U.S. manufacturers snare a major share of the emerging air-taxi market.” See Pasztor and Tangel, “U.S. Air Force Gives Lift”; see also Brian Garrett-Glaser, “Air Force to Begin Fly-Off, Certification Campaign for eVTOL Aircraft,” *Aviation Today*, February 21, 2020.
  69. In an *Aviation Today* article, Air Force acquisition chief Will Roper notes, “What we don’t want to happen is the same thing that happened in the small drone migration to China. It was a commercial technology, the Pentagon didn’t take a proactive stance on it, and now most of that supply chain has moved to China.” Garrett-Glaser, “Air Force to Begin Fly-Off”; see also Garrett-Glaser, “Through Agility Prime.”
  70. Brian Garrett-Glaser, “NASA Launches Urban Air Mobility Grand Challenge Program,” *Aviation Today*, August 30, 2019. NASA also has created and hosts several urban air mobility (UAM) working groups to periodically evaluate and discuss issues facing the UAM industry, including airspace access, physical infrastructure, and communications.
  71. “The DARPA Grand Challenge: Ten Years Later,” Defense Advanced Research Projects Agency, March 13, 2014, <https://www.darpa.mil/news-events/2014-03-13>.
  72. “NASA Gears Up for Advanced Air Mobility eVTOL Flight Testing,” *Aviation Week*, November 13, 2020.
  73. Susan Gorton, “NASA’s Advanced Air Mobility Mission with a Featured Guest from Mars, Ingenuity” (presentation, virtual luncheon meeting, Hampton Roads Chapter of the Vertical Flight Society, Hampton Roads, VA, April 23, 2021), [https://www.youtube.com/watch?v=3OJV\\_BLaBg8](https://www.youtube.com/watch?v=3OJV_BLaBg8). See minute 10.
  74. Gorton, “NASA’s Advanced Air Mobility Mission.”
  75. Charles Alcock, “Joby Powers Up eVTOL Program with \$2B IPO,” *AIRonline*, August 11, 2021.
  76. “Aerial Ride-Sharing: Joby Aviation on Safety, Noise, and the Future of Your Commute,” *DroneLife*, April 27, 2021.
  77. In the spring of 2021, UPS, for instance, said “it plans to purchase [eVTOL] aircraft from Beta Technologies to bolster its air service for small and mid-size markets.” The deal includes a purchase of 10 aircraft with an option to purchase

- up to 150 aircraft. See Eric Mandel, “United Parcel Service: Fleet of New Electric Aircraft Is ‘Foundation’ for Reducing Emissions,” *Jacksonville Business Journal*, April 9, 2021.
78. Deloitte Consulting LLP and National Aeronautics and Space Administration, *UAM Vision Concept of Operations*.
  79. Chloe Bennett, “Air Taxis and Drones: Why North Texas Is Teaming Up with NASA to Study Transportation,” *Dallas Morning News*, June 4, 2021. The participating agencies are the Massachusetts Department of Transportation, the Minnesota Department of Transportation, the Ohio Department of Transportation, the North Central Texas Council of Governments, and the city of Orlando.
  80. Adam Thierer, “‘Japan Inc.’ and Other Tales of Industrial Policy Apocalypse,” *Discourse*, June 28, 2021.
  81. See Government Accountability Office, “Unmanned Aircraft Systems: FAA Should Improve Drone-Related Cost Information and Consider Options to Recover Costs” (report no. GAO-20-136, Government Accountability Office, Washington, DC, December 2019); Antony Evans, Maxim Egorov, and Steven Munn, *Fairness in Decentralized Strategic Deconfliction in UTM* (Reston, VA: American Institute of Aeronautics and Astronautics, n.d.); Brent Skorup, “Auctioning Airspace,” *North Carolina Journal of Law and Technology* 21, no. 1 (2019): 79.
  82. Jim Moore, “Drone Rules on Final Approach: White House Reviewing Regs for Remote ID, Operations over People,” Aircraft Owners and Pilots Association, October 9, 2020.
  83. In an eVTOL article, researchers find that “total airport access demand is geospatially concentrated in certain areas.” Elon Head, “LAX Trips Emerge as a Promising Early Market for Urban Air Mobility,” eVTOL, June 9, 2021.
  84. Head, “LAX Trips.”
  85. Community-based rules for UAM traffic management “are developed by industry based on FAA guidelines and require FAA approval to address elements covered by FAA authority (for example, NAS safety, DCB, equitable access to airspace, security).” Federal Aviation Administration, *Concept of Operations Version 1.0: Urban Air Mobility (UAM)*, June 26, 2020, 7.
  86. Robin Riedel and Shivika Sahdev, “Taxiing for Takeoff: The Flying Cab in Your Future,” McKinsey & Company, January 2019. Document on file with authors.
  87. Brent Skorup, “Drone Technology, Airspace Design, and Aerial Law in States and Cities,” *Akron Law Review* (forthcoming).
  88. Skorup, “Drone Technology.”
  89. Government Accountability Office, *Unmanned Aircraft Systems: Current Jurisdictional, Property, and Privacy Legal Issues*.
  90. Skorup, “Drone Technology.”
  91. Brent Skorup “State Drone Laws Frequently Asked Questions” (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, June 2021), 2. See recommendation to state regulators to create drone sandboxes.
  92. “BCN Drone Center Segregated Airspace Expansion,” *sUAS News*, April 28, 2021.