Planepooling and Air Taxis for Post-COVID Aviation

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Abstract

For most of its history, commercial aviation has tended toward large airplanes, large airports, and rigidly scheduled flights. Now, however, two phenomena—technological innovation and long-term societal changes accelerated by the COVID-19 pandemic—are creating an environment in which many flight routes would be better served by "planepooling": smaller planes, smaller airports, and, for some routes, ad hoc scheduling. We highlight social and technological changes—including COVID-19 prevention measures, electrification of aircraft, and autonomous planes and air taxis—that could make private regional aviation attractive and affordable for business travelers and the middle class. Making planepooling convenient and cost-effective will require some technological advances and some changes in public policy. We propose in particular that regulators consider more-flexible Essential Air Service grants to small airports and the development of a market for regional aviation aerial corridors.

JEL codes: G38, L9, L90, L93, L98, O18, R4

Keywords: Regional travel, Aviation, FAA, Regional airports, Local airport, Air travel, COVID Private Aviation, Airspace, Auctions, Technology, Air Traffic Management

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Introduction

America's regional aviation could be at a tipping point, and it would be prudent for policymakers to plan for such an eventuality. For most of its history, commercial aviation has tended toward large airplanes, large airports, and rigidly scheduled flights. Now, however, two phenomena—technological innovation and societal changes associated with the COVID-19 pandemic—are creating an environment in which many flight routes would be better served by smaller planes, smaller airports, and, for some routes, ad hoc scheduling.

In the 1990s and early the following decade, the National Aeronautics and Space Administration (NASA), in cooperation with the Federal Aviation Administration (FAA), explored this concept of regional aviation transportation.[1, 2] The goal was to "enable people to move, faster and farther, anytime, anywhere," in small aircraft and "reduce inter-city doorstep-to-destination transportation time" by over 50 percent.[3]

Starting in 1998, aviation designer Burt Rutan and NASA aerospace technologist Bruce Holmes gave a series of presentations in Oshkosh, Wisconsin, under the title "Life after Airliners." Long before the advent of Uber and other ridesharing technologies, Rutan and Holmes outlined a vision of small airplanes (e.g., 4-to-8-seat propeller planes and jets) picking up and dropping off passengers at the thousands of small airports that dot the American landscape. This new breed of air carriers would operate in a manner that resembles the

[1] NASA, "Small Aircraft Transportation System (SATS)," accessed August 18, 2021, https://nasa.gov/centers/langley/news/factsheets/SATS.html.

[2] NASA, "Fact Sheet SATS: A Bold Vision," 2001.

[3] Research Board, *Future Flight: A Review of the Small Aircraft Transportation System Concept* (Special Report No. 263, Washington, DC: The National Academies Press, 2002).

earthbound UberPool—Uber's ad hoc carpooling service. Rutan and Holmes—and NASA—called this concept the "small aircraft transportation system" (SATS).[4] We call this Rutan-Holmes vision "planepooling," as it is an airborne analog of carpooling.[5]

In 2006, addressing the Richmond (Virginia) Forum,[6] Rutan outlined some specifics of such a system. He asserted that if we were starting American aviation from scratch, this vision is how we would do it. In his remarks, Rutan said that, despite the compelling arguments for this vision, we would be unlikely to transition from the current system to the one he outlined, because the transition costs would be too great. A sizable portion of our current fleet of airliners would be rendered redundant, and large-airport usage would plummet, putting both airlines and airports into financial jeopardy. On top of these barriers, investors and governments would have to build new fleets of perhaps ten thousand small airplanes, outfit hundreds or thousands of small airports for the increased demand, and hire hundreds or thousands of air traffic controllers to manage the airspace.

To date, however, the private commuter and on-demand small-plane industry has been fairly small, sandwiched between two larger, adjacent industry segments—regional airlines on the one

[4] NASA, "NASA Exhibits Preview Second Century of Flight," July 25, 2000.

[5] Holmes outlined the planepooling model in a definitive 2003 paper (Bruce Holmes, Michael Durham, and Scott Tarry, "Small Aircraft Transportation System Concept and Technologies," *Journal of Aircraft* 41, no. 1, July 2003, presented as Paper 2003–2510 at the AIAA-ICAS International Symposium on Air and Space—The Next 100 Years, July 2003). He listed six factors affecting twenty-first-century mobility: (1) saturation of the aviation system's hub-and-spoke infrastructure; (2) increasing gridlock on highways; (3) migration away from urban areas and airline hub cities; (4) baby boomers' demand for leisure travel; (5) a shift toward customization in services; and (6) increased value of human time. James Fallows wrote of Holmes's ideas just prior to the terrorist attacks of September 11, 2001, and in subsequent revisions of his book: James Fallows, *Free Flight: Inventing the Future of Travel* (New York: PublicAffairs, 2001). Holmes, he notes, touted small-plane systems as less prone to terrorism because "the vehicles aren't big enough to represent either a viable target or a viable threat to the ground." He said Holmes also observed that a decentralized, distributed aviation system would be more resilient—less prone to cascading failures, say, when operations at a major airport halt because of weather, mechanical failure, or other interruption.

[6] The first author of this paper was in attendance.

side and general aviation (e.g., recreational) pilots on the other.[7] The FAA recorded only about 500 planes certified for private commuter aviation in a 2012 study,[8] and an additional 6,400 planes were certified for private on-demand aviation,[9] so our focus is on this industry of around 7,000 aircraft. The average capacity of these planes is around 7 seats,[10] and most operators have a fleet of only 1 or 2 planes and fewer than 7 employees.[11]

Around 2005, a few companies had tried and failed at creating this mass-market "air taxi" model.[12] However, there have been many intervening changes since then that require a reassessment of that Rutan-Holmes planepooling vision. In particular, we highlight two shocks to the aviation system—COVID-19 and technology—that will have long-term effects on demand for planepooling and private aviation.

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[7] The safety and operating regulations for private commuter and on-demand operators resemble those for major commercial airlines more than those for general aviation. See, for example, JayEtta Z. Hecker, "GAO, Essential Air Service: Changes in Passenger Traffic, Subsidy Levels, and Air Carrier Costs" (Testimony Before the Committee on Transportation and Infrastructure, House of Representatives, Washington, DC, July 22, 2003). In 2017, 174 communities and small airports had Essential Air Service, and the service cost nearly $300 million annually in federal subsidies. See Rachel Y. Tang, *Essential Air Service (EAS)* (Report No. 44176, US Library of Congress, Congressional Research Service, Washington, DC, December 19, 2018). This commuter and on-demand segment should not be confused with the much larger "general aviation" industry, which also includes small planes, but general aviation renters and owner-operators are typically hobbyists and enthusiasts who are not permitted to fly passengers for compensation. In 2015 there were about 220,000 general aviation aircraft. However, this industry segment is shrinking; general aviation flight hours have declined nearly 40 percent since 1999, in part because of increasing costs of operations and aging hobbyists. In 2014, general aviation had about 18.1 million flight hours as a segment. See Frank Jackman, "Three Out of Four," *Flight Safety Foundation*, September 8, 2015. Some readers will remember the litigation and regulatory controversy regarding general aviation pilots offering flights for cost-sharing (that is, nonprofit) compensation, a service that gained popularity via ridesharing technology such as FlyteNow's. Our analysis focuses on the—separate—Part 135 industry, which operates flights for profit. For an excellent overview of the nonprofit flightsharing sector and its regulatory obstacles, see Christopher Koopman, "Defining Common Carriers" (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, 2017).

[8] US Department of Transportation, Federal Aviation Administration (FAA), *Study of Operators Regulated under Part 135*, 2016, fig. 2-1.

[9] FAA, *Study of Operators Regulated under Part 135*, fig. 2-1.

[10] FAA, *Study of Operators Regulated under Part 135*, fig. 2-1. Capacity records are not reliably collected by the government, but this is the capacity size indicated in accident reports. Only about 3,000 8–10-seat airplanes were built in the past decade. Jeremy Bogaisky, "Electric Aviation Trailblazer Bye Aims to Dethrone the King Air," *Forbes*, April 21, 2021.

[11] FAA, *Study of Operators Regulated under Part 135*, fig. 7-4. Only seven firms have more than 100 planes.

[12] Pogo Jet and Dayjet are two examples that folded during the Great Recession. See Matt Thurber, "Air-Taxi Plans a Nonstarter for Pogo Jet," *AINonline*, April 23, 2009; Chad Trautvetter, "It's Over: DayJet Files for Bankruptcy," *AINonline*, December 1, 2008.

First, the COVID-19 pandemic appears to be altering the economics of transitioning to a Rutan-Holmes world. The pandemic accelerated a long-standing migration out of large metropolitan areas and into suburbs,[13] and even rural areas, as the lockdown made life in urban areas less attractive and more costly. At the same time, the pandemic has increased the prevalence of remote work arrangements, which many employers may adopt as their new standard—further encouraging out-migration from large cities. Finally, social distancing may become a more permanent feature of our cultural preferences, with some consequent decline in the use of mass transit and people's propensity to visit large transportation hubs, including airports.

Second, technology advancements are working their way into aviation and small aircraft. These changes include the improvement and consumer adoption of ridesharing and booking software, electric-powered planes, new aircraft designs, and automated air traffic management systems. These coinciding advancements in technology have the potential to drive down the cost of small-plane operations significantly or make it easier to use commuter or on-demand private aviation.

These trends may tip the balance in aviation away from our current system and toward a Rutan-Holmes configuration. The COVID-19 pandemic introduced record numbers of leisure travelers and Americans of high net worth to the charter and private aviation business.[14] While private aviation will likely make large inroads in the next few years for wealthy families and top business travelers,[15] changing economics in aviation could make the market much larger. FAA

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[13] Joel Kotkin, "The Battle for Cities," *Tablet*, August 1, 2021, noting that, "Since 2012, suburbs and exurbs have accounted for about 90% of all metropolitan growth."

[14] As one private aviation executive put it, "If only the [top] 1% was flying prior to Covid-19, likely that has grown to the top 3% or more, based on request volume." See Eric Grossman, "In the Face of Covid-19, More Leisure Travelers Try Private Planes," *Market Watch*, July 25, 2020.

[15] Scott Suttell, "Flying Private Is Taking Off for Some Leisure Travelers Who Are Worried about Safety and Want Greater Convenience," *Crain's Cleveland Business*, July 27, 2020. The article notes that, "Recent statistics released by McKinsey show that over 90% of people who can afford to fly privately do not."

administrator Steve Dickson noted at a May 2021 House Appropriations hearing that the FAA is working with several advanced air mobility companies, and he anticipates some will be certified in 2023 and that operations could begin as early as 2024.[16]

We suspect social and technological changes in the next two decades could make private regional aviation attractive and affordable for business travelers and the middle class, much as deregulation and social trends opened airlines to the middle class in the 1980s and 1990s. The probabilities and possibilities are high enough that it behooves public officials and industry leaders to consider and anticipate the feasibility of such a transformation. Making planepooling convenient and cost-effective will require some technological advances and some changes in public policy. In particular, regulators should consider more-flexible grants to small airports and the development of a market for regional aviation aerial corridors.

1. The Nashville-to-Asheville Problem and Opportunity for Planepooling

Today's hub-and-spoke, large-airport/large-plane system serves the 1,000-mile-plus traveler well—but such long-distance travel accounts for only about 23 percent of flights (and about 41 percent of fliers).[17] Total time door-to-door means two to three hours of nonflight time for every flight. In short, for regional trips, "flying" today means spending significantly more time on the ground (in airports and in ground transportation) than in flight. This is an unintended consequence of creating a safe, high-throughput national aviation system, but the processes and policies that have built up over decades discourage regional travel. As a result, many business and leisure travelers are familiar with what we call the "Nashville-to-Asheville problem"—regional flights

[16] See House Appropriations Committee, "Federal Aviation Administration Safety Oversight Hearing (EventID=112593)," Youtube video, 1:42:00, May 12, 2021, https://www.youtube.com/watch?v=UrVHy_9jKAE (Exchange between Dickson and Rep. Mario Diaz-Balart beginning at around 1:42:00).

[17] Adie Tomer and Robert Puentes, "Expect Delays: An Analysis of Air Travel Trends in the United States" (Metropolitan Infrastructure Initiative Series, Brookings Institution, Washington, DC, October 2009).

between nonhubs are expensive, nonexistent, time-consuming, or irregularly scheduled. Under current circumstances, there simply is not enough demand to justify regular direct flights on many of these routes.

Furthermore, short flights present a business opportunity. They are often the least profitable routes and most likely to be cut by airlines' COVID-19 adjustments. Even a short hop requires a large airplane and 3 large, complex airports (assuming a change of planes). Because of COVID-19, flights between small cities have been canceled, which is especially damaging to local communities when the carrier is the dominant or sole carrier. A few US regional carriers, which make up about 40 percent of passenger departures in the United States and feed traffic to major hubs, went bankrupt, and others are under considerable financial stress.[18]

Current air travel patterns reveal that there is a large market for short hops and regional travel. Around 50 percent of today's flights are between cities 50 to 500 miles apart,[19] and that figure does not include the travelers and would-be travelers who would take advantage of more efficient, convenient air travel. Despite that 50 percent figure, Holmes estimates that 75 percent of the US population is not conveniently served, geographically and/or economically, by today's airline system. Charter and private aviation thrive in that distance: the typical business turboprop flight is around 270 miles.[20] However, today's private aviation is too expensive and booking is too inconvenient for most of today's travelers and would-be travelers.

Researchers at the Reason Foundation have noted that several ultralow-cost carriers are following a similar strategy in that they "target mostly unserved nonstop markets with affordable

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[18] Chris Woodyard, "The Coronavirus Travel Crisis Shuttered These Three US Airlines. Will More Go under as Well?," *USA Today*, May 14, 2021; Jon Sindreu, "Airline Aid Is Ending. Regional Flights May Suffer the Most," *Wall Street Journal*, September 11, 2020.

[19] Tomer and Puentes, "Expect Delays."

[20] Aviation consultant Rolland Vincent estimates such flights are around 240 nautical miles. See Bogaisky, "Electric Aviation Trailblazer Bye Aims to Dethrone the King Air."

jet service."[21] The article cited research by airline analyst Bill Swelbar of Swelbar-Zhong[22] about the market potential:

> In 2019, there were 665 U.S. city pairs with at least 30 passengers a day traveling between them but with no nonstop service. By June 2021 that number had increased to 885. Swelbar also noted the pandemic-related migration away from some of the country's largest metro areas, providing more residents of smaller cities who will still need to travel, for business as well as leisure.[23]

The Nashville-to-Asheville problem is national in scope and has grown since the beginning of the COVID-19 pandemic.

a. The Current Aviation System Is Inefficient for Short Hops

Prior to airline deregulation in 1978, federal regulators and major airlines kept the ticket prices of popular long-distance flights artificially high so the airlines would have surplus revenues to maintain service on unprofitable short-haul routes to small cities.[24] After deregulation, the major carriers abandoned many of the unprofitable short-haul routes and focused on high-traffic city pairs.[25]

The figure and tables here illustrate the differences between today's air travel (and automobile driving) and a hypothetical planepooling service. Take a hypothetical Mr. Smith in the Nashville suburb of Smyrna, who needs to visit work clients in Denver, Colorado, and in Asheville, North Carolina. According to Travelocity, the briefest Nashville-to-Denver flight (a distance of 1,013 miles) is 2 hours, 52 minutes. The briefest Nashville-to-Asheville flight

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[21] Robert Poole, "Aviation Policy News: Airport Privatization, Billionaires in Space, and More," Reason Foundation, July 27, 2021.

[22] Swelbar-Zhong Consultancy, accessed August 16, 2021, https://www.swelbar-zhongair.com.

[23] Poole, "Aviation Policy News: Airport Privatization, Billionaires in Space, and More."

[24] Glen Moore, *Commuter and Large Air Carriers: Is It Time for One Level of Safety?* (Washington, DC: US Library of Congress, Congressional Research Service, 1995).

[25] Moore, *Commuter and Large Air Carriers*. Lawmakers subsidize service on many of those legacy short-haul flights via the Essential Air Service program. See US Government Accountability Office, *Essential Air Service: Changes in Passenger Traffic, Subsidy Levels, and Air Carrier Costs*, 2019.

(a distance of 237 miles) takes 2 hours, 39 minutes, with a 37-minute layover and change of planes in Atlanta. Thus, the total Nashville-to-Denver in-transit time is only 8 percent longer than for the Nashville-to-Asheville trip, despite being over four times the distance.

But the initial wheels-up to final wheels-down flight time is not the only consideration. Smith must get from Smyrna to the Nashville airport—a 25-minute trip under ideal circumstances. He must navigate the airport, check luggage, go through the security queue, go through the sluggish boarding process, and leave extra time for delays at every step. Table 1 shows Smith's conjectural Nashville-to-Asheville trip.

Table 1 Spring 2021 air flight from Smyrna, Tennessee, to downtown Asheville, North Carolina

CDT	Segment of trip	Minutes	Miles
11:30	Departs in car service from home in Smyrna, TN		
12:30	Arrives at Nashville, TN, airport	60	
2:00	Flight takes off from Nashville, TN	90	
3:10	Flight lands in Atlanta, GA	70	214
3:47	Flight takes off from Atlanta, GA	37	
4:50	Flight lands in Asheville, NC	63	164
5:20	Departs in car service	30	
5:50	Arrives at hotel	30	
	Total travel time: 6 hours, 20 minutes		

The total flight time is 2 hours, 13 minutes, but Smith's total travel time, from leaving his house to arriving at his hotel, is 6 hours, 20 minutes. In addition, he must worry about a traffic jam on the way to the Nashville airport, delays at the airport, racing from gate to gate in Atlanta, and the possibility that the first flight will be late, causing him to miss the second flight. Of course, Smith also has to repeat the process in reverse on the way home.

Alternatively, according to Google Maps, Smith could have driven the 289-mile road distance from Nashville to Asheville in 4 hours, 21 minutes. He arrives in Asheville 2 hours earlier by driving than by flying. However, by driving, he cannot rest, send emails, sleep, play

games, and so forth en route. Smith must ask himself, ironically, "Should I drive, or do I have time to take a plane?"

Table 2 shows how things change if Smith drives himself.

Table 2 Drive from Smyrna, Tennessee, to downtown Asheville, North Carolina

CDT	Segment of trip	Minutes	Miles
11:30	Departs in car from home in Smyrna, TN		
5:51	Arrives at hotel in Asheville	291	289
	Total travel time: 4 hours, 21 minutes		

Millions of residents and businesspeople in hundreds of cities nationwide are in Mr. Smith's situation, and commercial aviation—despite cruising speeds of 500 mph—represents a longer, more frustrating trip than driving.

b. The United States Has a Large Number of Underutilized Small Airports

In 2019, the US Department of Transportation (USDOT) reported that there are just over 5,000 public-use airports and thousands more private-use airports.[26] They represent an underutilized national asset and dwarf the number of airports in other countries.[27] Most of these airports have few daily flights. Of the approximately 1,600 airports on which the FAA reports passenger data, nearly 1,200 reported fewer than 20 enplanements per day in 2019.[28] These airports range from modest regional airports such as Merced Regional in California to tiny general aviation airports such as Jimmy Stewart Field in Pennsylvania.

[26] There are over 14,000 private-use airports. See US Bureau of Transportation Statistics, "Number of U.S. Airports," Bureau of Transportation Statistics (dataset), April 29, 2021, https://www.bts.gov/content/number-us-airportsa. Confusingly, "private-use airports" can be privately or publicly owned. They are private use in that they can only be used upon invitation by the owner or manager of the airport. They are not held out for use by the public like public-use airports.

[27] The United States has nearly as many airports as the rest of the world combined. See Central Intelligence Agency, "Country Comparisons—Airports," *The World Factbook* (Washington, DC: US Government Printing Office, 2021).

[28] US Department of Transportation, Federal Aviation Administration, "Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports," August 12, 2021.

These small airports are typically pretty spare in terms of amenities—no food courts or retail kiosks; perhaps not even a ticketing gate.[29] However, many are well-suited for the regional aviation growth that we predict and anticipate. They are scattered in rural and suburban communities throughout the country, which means the average passenger lives significantly closer to a private-use airport than to a conventional large, public-use airport. Long waits for baggage and boarding are also nonissues, given the small planes these airports serve.

There is significant room for growth of private commuter flights. Excluding Alaska, whose remote geography and climate make it an anomaly, only 91 US airports recorded private commuter flights in 2012.[30] Of the top 20 US airports with private commuter flights, only 5 are in the contiguous United States—and 4 are associated with flights to and from Nantucket and Martha's Vineyard in Massachusetts.[31] These small airports around the country offer the potential for a much higher throughput of passengers if the technology and economics of small planes improve.[32]

An April 2021 NASA white paper[33] covers regional air mobility (RAM)—which largely overlaps with what we have called "planepooling"—in detail. Takeaways include: (1) "Only 30 of these [public-use] airports serve over 70% of all travelers"; (2) "A key requirement for widespread RAM is to dramatically reduce the operating cost of small regional flights"; (3) "Aircraft operating cost reductions of more than 50% are possible for RAM aircraft";

[29] And many do not have suitable runways for planes of the size we are discussing.

[30] FAA, *Study of Operators Regulated under Part 135*, fig. 8-5.

[31] For a passing cultural reference, the 1990 television series *Wings* revolved around a small commuter airline serving Nantucket, Massachusetts. For reasons unclear to us, Lambert-St. Louis International has a large number of private commuter flights. See FAA, *Study of Operators Regulated under Part 135*, fig. 8-7.

[32] In a 1998 slideshow presentation, "Life after Airliners II" (PowerPoint presentation, EAA AirVenture 1998, Oshkosh, WI, July 20–August 4, 1998), Bruce Holmes wrote that there is no lack of airspace to accommodate such regional flights and that "more approaches during more weather at more airports fully utilized 5,400 public use landing facilities can increase [national airspace system] capacity by more than an order of magnitude" (personal correspondence with author, July 16, 2020).

[33] NASA, "Regional Air Mobility," April 2021.

(4) “Electrified aircraft propulsion enables friendlier operations to the community”; (5) “The presence of electrically powered aircraft provides a catalyst for renewable generation at the airport”; (6) With small planes and airports, “the trip from your door to the airplane will be far more painless than your current trip to board an airplane at a major airport”; (7) “RAM is not waiting on some major breakthrough, but instead leverages trends and developments that are ongoing”; (8) “While developments are occurring on many fronts that will improve RAM, not all of them are required to be in place before some operations start to make sense”; (9) and “RAM can thrive in the presence of advances in other forms of transportation or transportation substitutes—enhanced telepresence, self-driving/electric cars, high-speed rail networks, advancements in large transport aircraft, and urban air mobility.”

In short, regional aviation using the thousands of underutilized public- and private-use airports would trim the 2- to 3-hour in-transit time to under an hour, or perhaps mere minutes, for regional travel. If regional travel were this convenient and rapid, demand would be induced.[34]

c. An Illustration: Planepooling from Suburban Nashville to Asheville

Now, let us imagine the same Nashville-to-Asheville trip via the Rutan-Holmes vision—enhanced by access to small airports and today’s technologies, aircraft design, ridesharing algorithms, and sundry innovations from fields outside aviation (see table 3). Together, these technologies allow much greater passenger throughput and safer, more efficient aircraft.

In this world, Mr. Smith wishes to fly, once again, from the Nashville suburb of Smyrna to downtown Asheville. He begins with an app on his phone, tablet, or laptop—much like today’s familiar Uber or Lyft apps. A car service picks him up at his home at 11:30 a.m. CDT, and he

[34] Agent-based modeling of transportation consumer behaviors in choosing travel modes has been used for airline studies and can be adapted to regional air mobility demand analyses. See the Air Markets Corporation home page, http://www.airmarkets.aero.

arrives at the tiny Smyrna airport 5 minutes later. Using an UberPool-like algorithm, the plane would have a few passengers from a previous stop. Boarding the plane is a relatively simple affair, with brief security measures and luggage handling. The plane flies to the Chattanooga suburb of Jasper, Tennessee, and lets a passenger out. After a 10-minute interlude, the plane flies to Pigeon Forge, Tennessee, and picks up a family of three. After another 10-minute wait, the plane flies to the Asheville airport. Smith departs by car service and arrives at his hotel.

Table 3 Indirect Rutan-Holmes/planepooling air flight from Smyrna, Tennessee, to downtown Asheville, North Carolina

CDT	Segment of trip	Minutes	Miles
11:30	Departs in car service from home in Smyrna, TN		
11:35	Arrives at Smyrna airport	5	
11:45	Plane takes off from Smyrna, TN	10	
12:45	Plane lands in Jasper, TN	60	80
12:55	Plane takes off from Jasper, TN	10	
2:15	Plane lands in Pigeon Forge, TN	80	127
2:25	Plane takes off from Pigeon Forge, TN	10	
3:10	Plane lands in Asheville, NC	45	58
3:20	Departs in car service	10	
3:50	Arrives at hotel	30	
	Total travel time: 4 hours, 20 minutes		

The total flight time is 3 hours, 5 minutes—52 minutes longer than in the traditional commercial aviation scenario, but the total travel time is 4 hours, 20 minutes—2 hours less than in that traditional scenario. In addition, planepooling eliminates many of the worries associated with the traditional flight. It is unlikely that traffic will much delay Mr. Smith's arrival at the Smyrna airport. If, by some chance, he is a few minutes late, the plane is not on a rigid schedule and will not leave without him. There will be no lengthy exercises in luggage handling, making his way through a large terminal, or clearing security. He does not have to change planes. A delay on one leg will not cause him to miss the next leg, and getting from the plane to his car service does not involve lengthy processes of disembarkation or luggage retrieval.

We expect that many such trips would be direct—with no stopovers to drop off or pick up passengers. If that were the case here, then the total trip would be 3 hours, 20 minutes—saving 2 hours, 30 minutes over traditional air travel—as shown in table 4.

Table 4 Direct Rutan-Holmes/planepooling air flight from Smyrna, Tennessee, to downtown Asheville, North Carolina

CDT	Segment of trip	Minutes	Miles
11:30	Departs in car service from home in Smyrna, TN		
11:35	Arrives at Smyrna airport	5	
2:10	Plane lands in Asheville, NC	145	224
2:20	Departs in car service	10	
2:50	Arrives at hotel	30	
	Total travel time: 3 hours, 20 minutes		

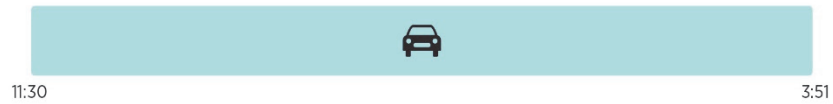
We show all four of these scenarios in figure 1.

Figure 1. Four Modes of Travel

(#1) Present-day airliner: Nashville to Atlanta to Asheville (6 hours, 20 minutes)

Source: Travelocity

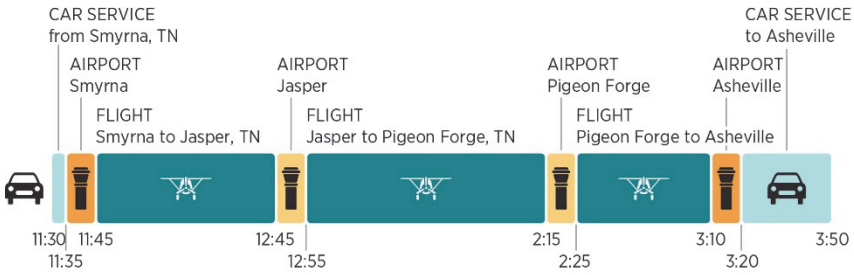
(#2) Drive Self from Nashville to Asheville (4 hours, 21 minutes)



Car travel takes 2 hours less than airlines, plus no fears of missed connections. But the traveler driving himself cannot work, rest, or read.

Source: Google Maps

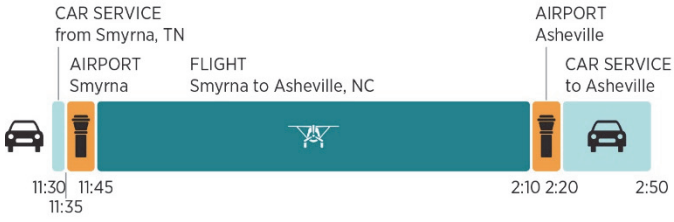
(#3) 8- to 10-seat planepool from Smyrna to Jasper to Pigeon Forge to Asheville (4 hours, 20 minutes)



Planepool passenger gets from Smyrna to Asheville in an 8- to 10-seat plane as quickly as by automobile and can work, rest, or read almost nonstop. The traveler never changes planes. Stops are only to pick up and drop off other passengers. Enplaning, deplaning, and getting to and from ground transportation are brief processes.

Source: Estimate by authors

(#4) 8- to 10-seat planepool, nonstop from Smyrna to Asheville (3 hours, 20 minutes)



In scenario 3, the plane makes stops to pick up and drop off other passengers in Jasper and Pigeon Forge. The authors expect that many trips would have only one stop or none. In scenario 4, there are no stops between Smyrna and Asheville.

Source: Estimate by authors

Note: In 2009, roughly half of flight departures, carrying 30 percent of passengers, were flights of under 500 miles. Of course, this does not measure the number of prospective short-haul passengers who choose not to fly because of the inconvenience and inefficiency.

The Nashville-to-Asheville problem is apparent nationwide. A cursory search of Google Flights provides real examples of the problem. Billings, Montana, to Helena, Montana, is 12 percent the distance of Washington, DC, to Denver—but the flight takes nearly 40 percent longer because of the need to connect via Seattle.[35] A typical daily flight from Akron, Ohio, to Columbus, Ohio, takes 6 to 9 hours because of a needed connection—50–130 percent longer than the departure-to-arrival time for Washington, DC, to Denver, despite constituting only 7 percent the distance. Sioux City, Iowa, to Dubuque, Iowa, requires the same departure-to-arrival length—again, because of a needed connection—despite being intrastate and 20 percent the distance of Washington, DC, to Denver.

Regular, small-plane trips across these megaregions would improve the economic connections within these areas. Regional aviation would also improve connections and enlarge the labor and product markets between these regions. Regulatory and competitive obstacles, though significant, are only part of the reason these regional routes are not regularly served. At present, there is not enough demand for these regional flights to justify operating and crewing even a small-body jet. However, things may be changing.

In 2000, NASA spokesman Keith Henry stated NASA's goal for a Rutan-Holmes small aircraft transportation system to "enable doorstep-to-destination travel at four times the speed of highways to 25 percent of the nation's suburban, rural and remote communities in 10 years and more than 90 percent in 25 years."[36] Of course, it is nearly 25 years since that statement, and little if any progress has been made.

[35] The distance between Billings and Helena is 175 miles. The flight takes 5.5 hours.

[36] NASA, "NASA Exhibits Preview Second Century of Flight."

2. Large Planes, Large Airports, and Pandemics

The COVID-19 pandemic and its spillover effects have changed the calculus of flying. This can be observed in five significant economic and cultural changes:

1. COVID-19 has increased the costs of living in the largest urban areas. Cities such as New York bore most of the pandemic's brunt during 2020. High-density living and daily reliance on public transit make big cities natural breeding grounds for the spread of infection. Adding to that, residents are forced to choose between claustrophobia—walled up in their apartments—or entering the streets with the constant challenges involved in maintaining social distancing. In less urbanized areas, streets are less crowded and safe outside spaces more widely available.
2. COVID-19 has decreased the benefits of living in urban areas. It has massively accelerated the acceptance of remote work arrangements. By reducing the number of people working in urban areas, it has increased the networking and career prospects of professionals in nonurban areas. The urban amenities that attracted so many young people and wealthy people to urban areas may never fully recover from the pandemic. Even with the advent of miraculously successful COVID-19 vaccines, use of the cities' big attractions—restaurants, bars, theaters, museums, shopping, schools, conferences, and hotels—may remain greatly diminished. As of April 2021, vast numbers of restaurants have closed permanently, others are imperiled by social distancing mandates (or consumer demands for space), and even fully vaccinated patrons are still hesitant to reenter these previously crowded spaces. Also, as of mid-2021, no one can yet say whether the pandemic has finished wreaking havoc. Many

questions remain. The US economy made an impressive recovery even as the pandemic raged, but those parts of the economy that rely on airplanes—business travel and vacations—remain diminished.

3. COVID-19 may do lasting damage to the act of making one's way through large airports to fly on large airliners. Airports have heretofore been densely packed places where social distancing is difficult to impossible. Airliners force passengers and crew members to share densely packed spaces with hundreds of people for prolonged periods. For an indefinite period, passengers will have to endure the discomfort of wearing masks for prolonged periods during flights and in airports. While it is possible that in-flight mask mandates may be rescinded, it will be some time before we know whether later waves of COVID-19 or mutated versions of it necessitate the reimposition of such mandates. For example, in July 2021, the city of Los Angeles reimposed mask mandates in response to more virulent strains of COVID appearing.[37]
4. COVID-19—or the memory of the pandemic—may make people minimize their use of the mass transit and other ground transportation services that carry them to and from airports.
5. COVID-19 has reduced the reasons for outsiders to visit urban areas. The diminishment of urban amenities and the discomforts of flying lessen the desirability of trips to urban areas. Of course, it is possible that vaccination and a retreat of COVID will reverse much of this effect, but it is also possible that residual risks and the memory of the COVID period will permanently reduce the desirability of urban destinations.

[37] Sharon Bernstein, "Mask Mandate Returns to Los Angeles as Coronavirus Cases Rise," Reuters, July 16, 2021.

All these factors boost current demand and create potential demand for more convenient flights between the currently inconvenient Nashville-to-Asheville type and other regional routes. Private aviation operators saw a large increase in interest and membership in 2020 and 2021 as wealthy urban leisure travelers sought alternatives to large planes and airports.[38] At the time of this writing, airline travel is still below prepandemic levels, while private aviation has gained market share and customers.[39] For instance, one CEO of a private jet company launched in 2019 noted, "Our business has been accelerating much more quickly than we would have anticipated had COVID not happened."[40] This shift of leisure and business travelers to private aviation and smaller airports may be permanent.[41]

First, there is the question of whether airplanes are disease vectors and whether the probability of contracting pathogens while flying is greater in large airports and large airplanes or in small airports and small airplanes. The likelihood of exposure during journeys to and from the airport also figures in the calculations. To date, airports and airlines do not appear to be significant sources of COVID-19 contagion, but the longer-term question is the extent to which concern over more virulent future pathogens enters the equation.

From the start of the pandemic, there have been concerns about whether flying poses a significant risk of contracting airborne pathogens like COVID-19. While the evidence is somewhat reassuring, there are caveats, and the evidence is not entirely conclusive. As of July

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[38] Grossman, "In the Face of Covid-19, More Leisure Travelers Try Private Planes"; Suttell, "Flying Private Is Taking Off for Some Leisure Travelers Who Are Worried about Safety and Want Greater Convenience."

[39] James Ledbetter, "How COVID Boosted Private Aviation—Permanently," *Worth*, June 3, 2021. Ledbetter notes that, "But while commercial airline travel remains deflated, the private aviation industry has actually surpassed, by many yardsticks, its prepandemic level."

[40] Ledbetter, "How COVID Boosted Private Aviation."

[41] Susan McKee, "Record Demand for Private Jet Flights Set to Continue," *Business Traveler*, June 22, 2021. In one industry survey McKee mentions, "Half of the current private aviation users said they had started or re-started private flying due to COVID, and 100 percent of these new private fliers say they plan to continue after the pandemic."

2021, mask mandates have not been lifted, and there are concerns over new variants of the COVID virus.[42]

The question of flight safety was of immediate concern when the pandemic began. On March 6, 2020, as the alarms were just beginning to sound, National Public Radio carried a story, part of which asked "to fly or not to fly?"[43] That early story noted the strength of air-purifying HEPA filters on commercial airlines. (Reporting the prevailing wisdom of the time, the article asserted that the virus was not airborne and would be spread largely from touching infected surfaces. That, of course, is no longer prevailing wisdom.)

As 2020 progressed, evidence suggested that the HEPA filters are generally quite effective. A September 2020 report indicated, for example, that flight attendants and other airline workers had lower rates of COVID-19 than the general population.[44] Cleaning and safety protocols gained high marks. A March 2021 report said that during the pandemic 3,500 flight attendants had tested positive for COVID and 20 had died.[45]

Concerns are not negligible, however, and have not receded. In March 2021, Robert Pearl, a physician and former CEO of the Permanente Medical Group, wrote an article titled "Covid-19 Flight from Hell: My Run-in with an Infected Passenger."[46] The account described a fellow passenger who was ill and a likely COVID sufferer. He described both the health risks and the flight crew's unwillingness to take action to isolate the sick passenger.

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[42] Leslie Josephs, "Airline Stocks, Boeing Tumble as Covid Cases Climb," CNBC, July 19, 2021.

[43] Adrian Ma, "Coronavirus Travel Tips: To Fly or Not to Fly? What Happens If You Cancel?," National Public Radio, March 6, 2021.

[44] David Slotnick, "CEOs Say It's Proof That Flying Is Safe," *Business Insider*, October 14, 2020.

[45] Ben Popken, "Flight Attendants Have Faced a Rough Year of Health Risks, Layoffs and Anti-maskers," MSNBC, March 16, 2020.

[46] Robert Pearl, "Covid-10 Flight from Hell: My Run-in with an Infected Passenger," *Forbes*, March 15, 2021.

In November 2020 (before any vaccines were available), an American Medical Association (AMA) blog post listed "6 things doctors wish patients knew about flying during the pandemic."[47] The post noted that airlines and airports are taking precautions, that airflow within airliners is powerful (more than even the ventilation systems in hospitals), with lower risk than in office buildings. (It is worth noting that even with widespread vaccination, concern over entering hospitals and office buildings remains.) The AMA post urged passengers to remain seated throughout the flight and always wear masks on the airplane and in the airport. The doctors quoted urged passengers to consider the risks outside the plane—in the airport and on public transportation to and from the airport—and their prevaccine advice was that staying home, if possible, was better than flying.

As of late April 2021, guidelines from the Centers for Disease Control and Prevention (CDC) specify that[48] the CDC recommends delaying travel until you are fully vaccinated, because travel increases your chance of getting and spreading COVID-19. If you are not fully vaccinated and must travel, follow the CDC's recommendations for unvaccinated people. Fully vaccinated flyers are advised to wear masks whenever in public, avoid crowds and people who are not your traveling companions, and wash hands frequently. Advice for unvaccinated individuals also involves pretravel and posttravel COVID tests and quarantine periods.

Each of these pieces of advice adds up to costs and inconvenience—even now that safe, highly effective vaccines have become a part of life. The CDC's advice also includes advice after arriving at one's destination.

[47] Sara Berg, "6 Things Doctors Wish Patients Knew about Flying during the Pandemic," American Medical Association, November 20, 2020.

[48] Centers for Disease Control and Prevention, "Domestic Travel during COVID-19," August 20, 2021.

In March 2021, the Mayo Clinic wrote, "Travel increases your chance of getting and spreading COVID-19. Staying home is the best way to protect yourself and others from COVID-19. If you must travel, talk with your doctor and ask about any additional precautions you may need to take."[49] The advisory adds, "Because of how air circulates and is filtered on airplanes, most viruses don't spread easily on flights. However, crowded flights make social distancing difficult. Plus, air travel involves spending time in security lines and airport terminals, which can bring you in close contact with other people."

As of July 2021, COVID restrictions have been significantly reduced. Mask mandates have fallen in many places. However, masks are still mandated for those traveling on airliners and in airports. In addition, new variants of COVID-19 (e.g., the "delta variant") are menacing civil life. In early July 2021, the Los Angeles city government reimposed mask mandates.[50]

In sum, the pandemic has changed the calculus for flying on commercial airliners—and for how long no one can say. Even with widespread vaccination, flying carries infection risks. Even for a vaccinated person, there are risks involved in taking public transport to and from airports, risks as one wends one's way through airports, and risks on airplanes. For now, and indefinitely into the future, travel involves considerably more inconvenience than was the case prior to the pandemic. For some trips (particularly overseas), this involves COVID testing, quarantines before and after trips, efforts to maintain social distancing at all points, and mask wearing while flying, all of which decrease the desirability of travel. Changes at travel destinations also may reduce the desirability of travel. Restaurants are fewer in number, and social distancing, masks, and other restrictions within them can make the dining experience less enjoyable. Bars, concert

[49] Mayo Clinic, "COVID-19 (Coronavirus) Travel Advice," August 20, 2021.

[50] Bernstein, "Mask Mandate Returns to Los Angeles as Coronavirus Cases Rise."

venues, and sports arenas may lack their previous electricity because of the dangers involved in singing, shouting, and togetherness. All of these may mean a permanent drop in air travel.

Some of these things may be true for travel by small plane as well. On some dimensions, present-day small planes may pose extra hazards. For example, many current small planes lack the sophisticated HEPA air purification systems that large planes have. However, eliminating the need for public transport to and from airports, being able to use smaller airports, less crowded check-in, and fewer fellow passengers may reduce risks.

But the key reason for invoking all the hazards and inconvenience of present-day air travel (large planes, large airports) is that one traditional impediment against a Rutan-Holmes aviation system has been the profitability of the current system of air travel. A vibrant, profitable existing system provides a strong motive against tampering with success. However, if the aftermath of COVID, combined with long-term demographic shifts out of major urban areas, results in a diminished commercial aviation system taking on water financially, that in itself may make an alternative system (small planes, small airports) viable for the first time. Add in the unrelenting increases in surface travel congestion, along with the evolving pressures from climate change and jet fuel's contribution to it, and the case for alternatives gains more strength.

The current hub-and-spoke system serves large cities well (for long-distance flights) and has served midsized cities feeding into the hubs relatively well. The need to change planes at the hub, however, has always been an inconvenient necessity during the system's 43 years. The premise behind the system was that air travelers are huddled around the hub cities and spoke cities. As we have noted, the Nashville-to-Asheville problem makes air travel at least as inefficient as driving.

Holmes noted in 1998 that Americans were migrating from cities to suburbs and from suburbs to rural areas and that this would place stress on the existing commercial aviation system and make the idea of a "small aircraft transportation system" more attractive. At that time, when the internet was still in its early stages as a mass consumer product, he foresaw the role of digital bandwidth as well as automation and digital connectivity in fueling the change. What Holmes could not foresee in 1998 was the emergence of battery-electric and hydrogen fuel cell powertrains for small aircraft and its increased momentum.[51]

With the COVID-19 pandemic, that migration became a leading story. An August 2020 essay by James Altucher raised hackles and went viral when he declared, "New York City is dead forever."[52] Altucher cited the aftereffects of lockdowns—shuttered restaurants, theaters, and museums, and the collapse of commercial real estate prices with the sudden uptick in remote work. Echoing Holmes's point from 22 years earlier, Altucher cited "bandwidth" as what he perceived to be a mortal blow to the city's full return. The Zoom revolution in business meetings is only possible now because bandwidth has increased sufficiently to carry huge volumes of video. Altucher wrote, "Nobody wants to fly across the country for a two-hour meeting when you can do it just as well on Zoom. I can go see 'live comedy' on Zoom. I can take classes from the best teachers in the world for almost free online as opposed to paying $70,000 a year for a limited number of teachers who may or may not be good." (Altucher himself is a comedy club owner and former hedge fund manager.) Of course, a substantial retreat of COVID may partially reverse these trends, but the question is by how much. Remote work has become quite popular over the course of the pandemic.[53]

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[51] Correspondence with Bruce Holmes, May 7, 2021.

[52] James Altucher, "New York City Is Dead Forever," *New York Post*, August 17, 2021.

[53] Matthew Haag, "Remote Work Is Here to Stay," *New York Times*, March 29, 2021.

A March 2021 Federal Reserve Bank of Cleveland publication documented the extent of migration.[54] It compared population flows from April 2020 to December 2020 with the same period in earlier years and found that,

> The percentage changes support the hypothesis that during the pandemic, people increased their migration toward regions with lower housing costs. Gross migration flows from the high-cost, large metro areas increased by 5.6 percent toward lower-cost, large metro areas. The flows from high-cost, large metro areas to midsized metro areas increased by 10 percent, and the flows to small metro areas and rural regions increased by approximately 9 percent.

A February 2021 article in *The Hill* declared, "Rural America booms as young workers leave the cities behind."[55] The article continued, "The recent urban exodus has resulted in an accumulation of human and financial capital, flush with talent and dollars, for rural America" and "The net rate of arrivals and departures for major cities is devastating. New York, which lost 4 percent of its population over the last year, has watched about five people leaving for every four people arriving. San Francisco has seen 20 percent more people leaving than arriving, as Seattle and Boston each had about 10 percent more people leaving than arriving." The author's data indicate that for some years prior to the pandemic, the fastest-growing cities were smaller and largely without airline hubs.

Harking back to the Nashville-to-Asheville problem cited earlier, it appears that a great number of Americans are seeking quieter, less expensive existences in places very much like Knoxville, Tennessee, and Austin, Texas, and many of these people appear to be high earners. If out-migration from cities and suburbs was having an erosive effect on the hub-and-spoke system in the first two decades of the century, COVID-19 produced an avulsive effect—a large, sudden change in market patterns. In November 2020, the McKinsey consulting group asked, "Will

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[54] Stephan Whitaker, "District Data Brief: Migrants from High-Cost, Large Metro Areas during the COVID-19 Pandemic, Their Destinations, and How Many Could Follow," Federal Reserve Bank of Cleveland, March 25, 2021.

[55] Kristin Tate, "Rural America Booms as Young Workers Leave the Cities Behind," *The Hill*, February 22, 2021.

airline hubs recover from COVID-19?"[56] They predicted that the hub-and-spoke model would survive but with altered strategies. They noted a particular drop-off in connecting passengers and a shift toward direct flights. At the time, the number of connecting passengers had dropped by 81 percent over the previous year, versus a 61 percent drop-off in passengers on direct flights. As McKinsey wrote, "Passengers are also exhibiting a stronger preference for nonstop travel, both to avoid the perceived double risk of contracting the coronavirus and because the increased complexity of travel restrictions and quarantine rules can be confusing to even the hardiest traveler. On the supply side, the limited flight schedules currently in place have broken the connecting banks of many airlines." Time will tell, but we believe some of this consumer behavior will be long-lasting.

In February 2021, *Bloomberg News* described other demand shifts.[57] Passenger growth in the 9 months following the nadir of travel (April 25, 2020) remained slow, with 30 percent of the world's commercial aircraft sidelined. Business travel had plummeted, replaced to some extent by leisure travel—with a preference for direct routes.

In accordance with that, in November 2020, Bill Gates predicted that 50 percent of business travel would disappear in the post-COVID world.[58] Zoom meetings will take their toll on the hub-and-spoke system and consumer tolerance for it. With implications for the migration to rural areas, Gates also predicted that 30 percent of days in the office would go away in the wake of the pandemic.

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[56] Jaap Bouwer, Vik Krishnan, and Steve Saxon, "Will Airline Hubs Recover from COVID-19?," McKinsey & Company, November 5, 2020.

[57] Eric Rosen, "Airlines Are Ditching Business Hubs and Rerouting Flights to Florida," *Bloomberg News*, February 8, 2021.

[58] Noah Higgins-Dunn, "Bill Gates Says More Than 50% of Business Travel Will Disappear in Postcoronavirus World," CNBC, November 17, 2020.

Globetrender reported in December 2020 that one-third of airline routes worldwide have vanished, noting that, "Unprofitable routes, usually to less-populated destinations, have been first to go. It reflects the bleak reality that carriers have to face as demand is not expected to recover until 2024 and has led to fleet downsizing and mass layoffs. Simultaneously, these difficult decisions put entire communities at risk of being cut off."[59] The report also noted that a considerable number of airlines have ceased operations since the COVID outbreak began.

By November 2020, US airline employment had plummeted to lows not seen in decades.[60] Worldwide, airline industry revenues plummeted.[61] As of April 2021, airline layoffs in the United States had eased as a result of President Biden's stimulus package.[62] Whether that will endure remains to be seen.

As of this writing, the reduction in traffic through America's hub-and-spoke system is an ongoing story. With the rapid deployment of COVID vaccines, perhaps the airlines' travails will lighten, but there is a good probability that they will not. The migration toward places ill-served by airlines has been going on for decades, and COVID merely accelerated the process. At the time of this writing in 2021, one cannot say whether the virus will fade away or whether it will persist, making today's extreme precautions a long-lived trend. For now, the precautions have made large airports and airplanes something to avoid for some would-be travelers, both because of the risk of infection and the inconvenience factors of protracted mask wearing, testing, and an expanding gauntlet of safety protocols at various steps along the way during a trip. And for those

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[59] Olivia Palamountain, "One in Three Airline Routes Have Been Lost Due to Covid-19," *Globetrender*, December 8, 2020.

[60] Leslie Josephs, "U.S. Airline Employment to Reach Lowest Levels in Decades after Pandemic Cuts 90,000 Jobs," CNBC, November 12, 2020.

[61] Jon Victor, "Laid-Off Airline Workers Mull Post-COVID Job Options as Industry Languishes," *CTV News*, March 16, 2021.

[62] Eli Rosenberg, "Companies Are Scaling Back Layoffs Because of Biden's Stimulus Package," *Washington Post*, March 11, 2021.

willing to endure these risks and protocols, there is still the likelihood that many air routes will have vanished because of the virus.

3. New Technologies

While there has been a shift toward private aviation by leisure travelers with high net worth, private aviation fees are out of reach for most business and leisure travelers.[63] However, there are several technologies rapidly maturing that will bring about something resembling the Rutan-Holmes idea and drive down costs. Ridesharing is one, but so are aviation automation (provided by onboard systems or remote pilots),[64] aircraft design and passenger drones, electrification, and automated air traffic management. These technologies were in the lab or mere ideas 15 years ago, but today they have been commercialized or are in commercial testing. Their parallel development will one day allow much greater passenger throughput and safer, more efficient small aircraft.

a. Ridesharing and Private Terminals

In the past few years, dozens of companies have expanded into the on-demand, fractional ownership, and "jet card subscription" private jet market.[64] Generally, these operations are the "part 135 industry," which refers to the FAA's regulatory classification for small planes and jets that provide scheduled or on-demand air taxi flights.[65] The business models differ: some

[63] In a 2021 industry survey of private aviation users, over 90 percent used jet card membership programs, and the average deposit for a jet card exceeded $230,000. See McKee, "Record Demand for Private Jet Flights Set to Continue."

[64] See Doug Gollan, "Private Jet Fractional Ownership and Leases—a Complete Guide," Private Jet Card Comparisons, October 15, 2019, https://privatejetcardcomparisons.com/2019/10/15/private-jet-fractional-ownership-and-leases-a-complete-guide/.

[65] In 2012, there were over 10,000 part 135 aircraft, of which 3,300 were fixed-wing jet planes. See FAA, *Study of Operators Regulated under Part 135*.

companies match riders with pilots, some sell "empty legs,"[66] some sell subscriptions to charter flights, some sell fractions of jet ownership, and some sell fixed hours of charter flights.[67] What drives the growth in these services is that internet-based technology makes these previously paper-based and manual business models much more convenient for a national customer base. Some firms have now unveiled Uber-like apps for shared flights, for instance.[68]

There are also several new scheduled shuttle operations that have similar business models, using ridesharing technology and the ease of private terminals and general aviation airports to attract new customers and bring down costs.[69] Operators have scheduled flights between nonhubs such as White Plains, New York, and Nantucket, Massachusetts, an hour-long flight, and Westchester County (New York City area) to Syracuse, New York.[70] Passengers can be at the airport as little as 15 minutes before departure.[71] Prices today are typically $650 to $3,500 per seat, plus an annual membership fee of a few thousand dollars.[72] These costs make the private jet market beyond the means of a middle-class family, but the several companies in this sector show that there is untapped demand for semischeduled small-plane flights between nonhubs. The

[66] Empty legs refer to the private jets that are returning to a destination after dropping off a customer. Empty legs generate no revenue, and charter operators will sometimes sell seats on these routes at large discounts to noncustomers. See Doug Gollan, "Private Jet Empty Legs: What You Need to Know Before You Buy," Private Jet Card Comparisons, August 2, 2020, https://privatejetcardcomparisons.com/2020/08/02/private-jet-empty-legs-what-you-need-to-know-before-you-buy/.

[67] See Henry Fernandez, "On-Demand Private Jet Service Will Shuttle Passengers for $600," *Fox Business*, July 3, 2019. Companies in this on-demand and ridesharing jet segment include Flewber, UberJets (no connection to Uber the car ridesharing company), Blackbird, BLADE, TapJets, XO Jets, and Wheels Up.

[68] See Doug Gollan, "Reviewing the Wheels Up Private Jet Booking App," Private Jet Card Comparisons, April 5, 2021, https://privatejetcardcomparisons.com/2021/04/05/reviewing-the-wheels-up-private-jet-booking-app/.

[69] These companies include JSX, Tradewind Aviation, and Surf Air. See Doug Gollan, "Wheels Up, Jet Linx, and XO: Comparing the Private Jet Sharing Options," Private Jet Card Comparisons, September 30, 2019, https://privatejetcardcomparisons.com/2019/09/30/wheels-up-jet-linx-and-xo-comparing-the-private-jet-sharing-options/. JSX, for instance, is a "semiprivate" airline that uses 30-passenger aircraft and private terminals that customers find much more convenient than traditional commercial airlines. See Tyler Hayes, "Semiprivate Flying on JSX Is Your Best Travel Hack," *Newsweek*, May 1, 2021.

[70] Gollan, "Wheels Up, Jet Linx, and XO."

[71] Gollan, "Wheels Up, Jet Linx, and XO."

[72] Gollan, "Wheels Up, Jet Linx, and XO."

introduction of the following technologies and policies should drive prices down further and make this a mass-market service.

b. Electrification and Aircraft Design

Aviation manufacturers are designing new air taxi aircraft, often with electric power trains, which have lower maintenance costs and manufacturing complexity than current jet or propeller shuttle aircraft. Most of these innovators are building battery-electric systems, but some companies are beginning to develop hydrogen-electric systems. A few companies are also creating entirely new aerodynamic aircraft powered by petroleum fuel. There are two approaches: some companies are retrofitting existing aircraft with electric systems, and some are designing new (electric or fuel) aircraft from scratch.

In the first category, a company called MaginX, for instance, is designing electric propulsion systems for existing fixed-wing aircraft for flights between 50 and 1,000 miles.[73] MaginX completed testing of a prototype in Washington State in 2020, the first electric aircraft of its type to fly at an altitude of 8,000 feet.[74] The company is designing propulsion systems for several types of existing aircraft and expects to fly a new prototype in 2021.[75] Though not as developed, several new and established companies are working on hydrogen-electric fuel for charter and regional planes.[76] Other hydrogen fuel cell power train developers include Universal Hydrogen and Alakai Technologies, as well as rumored work by Hyundai and Toyota.[77]

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[73] Charles Alcock, "MagniX Sees Regional Operators as Electric Aviation Pioneers," *AINonline*, August 10, 2020.

[74] Alcock, "MagniX Sees Regional Operators as Electric Aviation Pioneers."

[75] Alcock, "MagniX Sees Regional Operators as Electric Aviation Pioneers."

[76] See Mark Harris, "ZeroAvia's Hydrogen Fuel Cell Plane Ambitions Clouded by Technical Challenges," *TechCrunch*, April 14, 2021.

[77] Personal correspondence with Bruce Holmes, May 7, 2021.

Bye Aerospace is designing an 8-seat battery-electric plane to compete with the top-selling traditional plane of that class, the Beechcraft King Air.[78] The King Air is a reliable workhorse, but some of the aircraft still in operation date to the 1960s and are gradually being retired. Bye Aerospace representatives believe their plane will sell at a price similar to that of the King Air but at one-fifth the operating cost, given the more aerodynamic design and relative simplicity of electric motors.[79] By retrofitting existing aircraft (the MaginX approach) or designing electric aircraft very similar to existing aircraft (the Bye approach), this new breed of electric aviation companies can likely avoid much of the long and costly process of seeking new aircraft certifications from federal regulators.

In the second category, totally new aircraft designs, including electric vertical takeoff and landing (eVTOL) aircraft, are in development. Lilium, for instance, is designing a 7-seat eVTOL aircraft with a 155-mile range,[80] which would make the New York City to Philadelphia flight less than 30 minutes.[81] Vertical Aeroscope is designing a 5-seat eVTOL aircraft in the United Kingdom. Company reps believe the aircraft would fill a need for short hops such as London to Brighton, shortening the 1-hour train ride or 2-hour car ride to 30 minutes by air, and for half the cost per passenger-mile of a helicopter.[82] Virgin Atlantic has partnered with the manufacturer,

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[78] Bogaisky, "Electric Aviation Trailblazer Bye Aims to Dethrone the King Air."

[79] Bogaisky, "Electric Aviation Trailblazer Bye Aims to Dethrone the King Air."

[80] Jason Pritchard, "Munich Airport and Nuremberg Airport to Become Hubs for Lilium's Planned Regional Air Mobility Network in Southern Germany," *EVTOL Insights*, April 19, 2021.

[81] Brian Garrett-Glaser, "What the First Passenger Air Taxi Services Will Look Like," *Aviation Today*, August 18, 2020.

[82] Michael Cogley, "Why the Flying Car Revolution Is Finally All Set to Take Off," *Financial Review*, November 4, 2020. Helicopter costs are about $10 per seat-mile for 6-passenger aircraft. See Dean Donovan, "Why Porsche and Boeing Likely Won't Make a Personal Flying Sports Car," *Forbes*, October 14, 2019. In contrast, "Vertical [Aerospace] is targeting $1.06 per seat-mile—less than Lilium's projected $1.75 per seat-mile cost and even Joby's $1.27. 'We are confident that we will build an aircraft capable of flying a 25-mi. journey at an operating cost of just over $100 per aircraft,' [Vertical Aerospace CFO Vinny] Casey says." See Graham Warwick, "Vertical Ambition," *Aviation Week and Space Technology*, June 28, 2021.

and American Airlines has reportedly made conditional orders of Vertical Aeroscope aircraft.[83] Similarly, in February 2021, United Airlines and Archer Aviation announced a partnership aimed at developing electric air taxis for short-haul trips,[84] and established companies such as Hyundai are also creating new designs.[85]

Not all new designs are battery- or hydrogen-powered. The manufacturer of the Celera 500L, for instance, has a novel aerodynamic design for its diesel business aircraft. Nevertheless, it represents a major departure from traditional business jet designs. The company estimates that its 6-passenger aircraft will cost under $350 per hour to operate, compared to $1,300 to $3,000 hourly for a traditional charter plane or private jet.[86] Not all these new entrants will succeed, but significant new investments in new, lower-cost aircraft designs are being made.

c. Automated and Remote-Operated Planes and Passenger Drones

Several startups and established airlines have begun commercial drone delivery programs with remote-operated and autonomous parcel delivery drones.[87] For instance, Zipline, an international medical drone delivery company, can operate 24 drone deliveries at once with a single remote operator, an operator-to-drone ratio that is regularly improving.[88] The success with this

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[83] Hanna Ziadt, "American Airlines and Virgin Atlantic Order Electric Air Taxis from UK Startup," *CNN Business*, June 11, 2021.

[84] United Airlines, "United to Work with Archer Aviation to Accelerate Production of Advanced, Short-Haul Electric Aircraft," February 10, 2021, https://hub.united.com/2021-02-10-united-to-work-with-archer-aviation-to-accelerate-production-of-advanced-short-haul-electric-aircraft-2650426294.html.

[85] Hyundai Motor Company, "Uber and Hyundai Motor Announce Aerial Ridesharing Partnership, Release New Full-Scale Air Taxi Model at CES," Cision PR Newswire, January 6, 2020, https://www.prnewswire.com/news-releases/uber-and-hyundai-motor-announce-aerial-ridesharing-partnership-release-new-full-scale-air-taxi-model-at-ces-300981947.html.

[86] Stephen Johnson, "New 'Bullet Plan' Aims to Make Private Flights Affordable," *Big Think*, September 1, 2020.

[87] See Ben Coxworth, "Yamaha and Japan Airlines Trial Same-Day Seafood Delivery by Drone," *New Atlas*, April 8, 2020; "ANA to Start Drone Delivery Service as Japan Eases Regulations," *Nikkei Asia*, April 14, 2021; "AirAsia to Launch Air Taxi and Drone Delivery Service," *Nikkei Asia*, March 6, 2021.

[88] In 2016, Harrison Wolf, Director of Global Aviation Policy at Zipline International, stated Zipline's operator-to-drone ratio was 1-to-4. See Harrison Wolf, "Tomorrow's Transportation, Today: How Zipline Leverages Autonomy to Redefine Health Logistics and Where We Go from Here" (lecture, AUVSI Xponential Conference, Atlanta, GA, May 4, 2021).

technology is giving investors and regulators confidence in the development of larger aircraft that are designed to carry freight or passengers.[89] In early 2021, for instance, a US company demonstrated the first "gate-to-gate" autonomous flight, with a retrofitted Cessna.[90] Startup Merlin Labs has a contract from Dynamic Aviation, a large fleet operator, to modify dozens of King Airs for autonomous operation.[91]

Passenger drones and remote-operated eVTOL aircraft build on many of the technologies already mentioned and are gaining regulator and investor interest. In the United States, regulators anticipate passenger drones could begin operations as early as 2024.[92] At the time of this writing, a Chinese drone manufacturer, EHang, had completed 10,000 flights of its autonomous 2-person passenger drone and the model was in production.[93] In the US market, tech companies and manufacturers are teaming up for automated and remote-piloted aviation services.[94] One aviation company plans to test autonomous freight aircraft in the United States in early 2022.[95]

d. Airspace Design and Automated Airspace Management

Traditional air traffic control (ATC) handles about 5,000 flights daily. Air traffic management is becoming more digitized—in 2021, London City Airport became the first international airport to

[89] "Investors are pouring money into urban air mobility (UAM) companies in the expectation that they will be ferrying passengers around cities by the middle of this decade." See John Thornhill, "Flying Cars Finally Prepare for Take-Off," *Financial Times*, April 15, 2021.

[90] Greg Nichols, "First Gate-to-Gate Autonomous Airplane Flight," *ZDNet*, April 15, 2021.

[91] Graham Warwick, "Unmanning the King Air," *Aviation Week and Space Technology*, June 14, 2021.

[92] See House Appropriations Committee, "Federal Aviation Administration Safety Oversight Hearing."

[93] See Elan Head, "EHang Confirms Plans for Winged eVTOL and Piloted Version of EH216," *EVTOL*, April 16, 2021.

[94] Wheels Up, a ridesharing company, announced plans to launch flight scheduling with Bell, a manufacturer in the private aviation and eVTOL aircraft markets. See Chad Trautvetter, "Wheels Up, Bell Collaborate over Urban Air Mobility Services," *Future Flight*, April 13, 2021.

[95] Andy Pasztor, "To Build a Plane That Can Fly Itself, Start with a Pilot in the Cockpit," *Wall Street Journal*, August 20, 2020.

have remote air traffic control—in order to improve reliability and throughput.[96] Automation will be needed to avoid overwhelming ATC with tens of thousands of new commercial regional flights. Regulators acknowledge the issue, and the FAA and NASA have proposed a private (with FAA oversight) and federated system of unmanned traffic management (UTM) to coordinate unmanned drone and passenger drone flights.[97]

To simplify the traffic management system and keep it separated from traditional aviation air traffic control aircraft, the FAA has proposed demarcating low-altitude aerial corridors for passenger drones and short-hop flights.[98] The initial plans anticipate that rules for operations within the corridor—say speed, how to share "lanes," and what to do when a landing area is congested—will be "collaboratively developed" by industry and approved by the FAA.[99] The details, however, are scant as of this writing.

Each UTM system will cover a geographic area, say a city or a county, or an aerial corridor and ensure separation between aircraft within the corridors. There is also a proposal, discussed in Mercatus publications[100] and by the GAO[101] and Airbus,[102] for the federal government to auction

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[96] Sixteen high-definition cameras were installed on a new onsite control tower, which transmits the audiovisual information 90 miles to a control center. The center's panoramic arrangement of computer screens allows air traffic controllers to monitor the skies and runways remotely. See Sarah Young, "Ground Control Out, Remote Control in at London City Airport," Reuters, April 29, 2021.

[97] "[F]or [urban air mobility] operations, tactical separation within UAM Corridors is allocated to the UAM community with no tactical ATC services provided by the FAA." The FAA refers to private traffic management systems in surface airspace as "UTM" but refers to such systems in higher-altitude airspace as "provider of services for UAM" (PSU). We use UTM to describe private traffic management systems for aircraft in both surface and high-altitude airspace. See US Department of Transportation, Federal Aviation Administration, *Urban Air Mobility (UAM) Concepts of Operations*, version 1.0, 2020.

[98] NASA researchers had described this "management by closed trajectory" method as a way to automate air traffic management. It is unclear how long the separation of aviation users will last, though NASA and the FAA hope it will be temporary. See FAA, *Urban Air Mobility (UAM) Concepts of Operations*.

[99] FAA, *Urban Air Mobility (UAM) Concepts of Operations*.

[100] Brent Skorup, "Auctioning Airspace," *North Carolina Journal of Law & Technology* 21, no. 1 (October 2019): 79–113.

[101] US Government Accountability Office, *Unmanned Aircraft Systems: FAA Should Improve Drone-Related Cost Information and Consider Options to Recover Costs*, December 2019.

[102] Airbus, "Understanding Fairness in Unmanned Traffic Management," accessed August 18, 2021, https://www.airbusutm.com/airspace-fairness.

or lease those aerial corridors to regional or urban air taxi companies. Corridor leases would raise revenue, prevent anticompetitive "route-squatting" by first movers and ensure market-based disposition of this public resource.[103]

4. Aviation Policy Recommendations

US regulators expect these new aircraft to be certified and operational in the next few years, but policy changes are needed to prevent these aircraft and systems from becoming mere curiosities.[104] The following three recommendations can be accomplished in the near term.

a. Expand Use of the USDOT's New Transportation Council

First, the USDOT and other transportation experts should examine the possibility and feasibility of regional aviation in light of recent social and technological changes. In 2018, the USDOT created the Non-traditional and Emerging Transportation Technology Council, composed of top transportation officials. To date, the council has working groups analyzing hyperloop trains and urban air mobility[105] but seems underutilized. The council seems like a good forum for this sort of work. This includes the following:

- Evaluating whether today's private-use airports can sustain passenger throughput under a few demand scenarios.
- Estimating the financial impact on present-day airliners and airports, including airport financing, passenger facility charges, and the Airport Improvement Program, under a few demand scenarios.[106]

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[103] Brent Skorup, "Auctioning Airspace."

[104] See House Appropriations Committee, "Federal Aviation Administration Safety Oversight Hearing."

[105] See US Department of Transportation, "Overview: NETT," last modified January 15, 2021, https://www.transportation.gov/nettcouncil.

[106] Private aviation users are typically affluent, and it is generally regressive to use federal passenger facility charges from users of large airports to subsidize facilities of private aviation users. In a world of more private aviation traffic, it may be time to put more small-airport financing costs onto the users of small airports. Our thanks to an anonymous reviewer for raising this issue.

- Configuring small planes to minimize the spread of contagion (by introducing HEPA filters, for example).
- Estimating the personnel needs of such a system—including a rapid increase in the number of available pilots.
- Investigating whether 5G, new satellite systems, and future wireless technologies can supplement existing systems for regional aviation.
- Investigating the potential economies of scale in manufacturing large numbers of small planes.

Planning for such a world also entails good, hard looks at the various contingencies, caveats, and risks.

- Could contagion risks be higher on small planes than on large ones with advanced air filtration systems and cleaning services?
- Can the country produce a sufficient number of pilots quickly enough to make such a transition possible? Alternatively, how will consumers adapt to pilotless air transportation options?
- What form of aeronautical industrial transformation is required to support the transition from very low-rate manufacturing economics of today to high-rate manufacturing of air vehicles in the future?
- Are there significant risks involved in the simultaneous increase in small-plane and drone traffic?

b. Liberalize the FAA's Essential Air Service Program

Second, Congress and the FAA should liberalize the FAA's Essential Air Service program by shifting funding to the Alternate Essential Air Service subprogram and expanding the subprogram's eligibility to more cities. The traditional Essential Air Service program is a long-running federal program created after airline deregulation that disburses grants in order to

maintain air service to a community. Today, there are about 180 airports receiving service under the program.[107]

The Alternate Essential Air Service program is a novel addition to the larger program. In 2003, Congress amended its aviation subsidy law to allow the FAA to give Essential Air Service grants directly to a city rather than via the traditional method—subsidizing a carrier serving that city.[108] Congress limited the subprogram to only 10 cities, however. Currently, seven cities participate, and they have significant freedom in using those funds. Critically, each participating city has chosen to use those funds to contract with operators and create a public charter service.[109] The program allows cities and operators more flexibility in their subsidized air operations.[110]

The FAA and USDOT should allow more participating communities to opt into the Alternate Essential Air Service program if their existing subsidized service is not working well. Instead of more funding, this program needs liberalized eligibility rules for cities and more prioritization from the FAA as the planepooling and air taxi industries develop. In particular, the FAA should reach out to private carriers and electric aircraft companies to advertise this niche program. The FAA should incorporate the technological and social changes we have discussed into its future plans for the program so that communities are getting cost-effective and

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[107] In fiscal year 2018, there were 108 participating communities in the contiguous United States and 65 communities in Alaska and Hawaii. See US Government Accountability Office, *Commercial Aviation: Effects of Changes to the Essential Air Service Program, and Stakeholders Views on Benefits, Challenges, and Potential Reforms*, December 2019.

[108] Community and regional choice programs, 49 U.S.C. § 41745 (2003).

[109] Beckley, WV; Crescent City, CA; Macon, GA; Manistee/Ludington, MI; Page, AZ; Parkersburg, WV/Marietta, OH; and Tupelo, MS. See Tang, *Essential Air Service*.

[110] Tupelo, for instance, upgraded to larger jets with their grant, something they could not do under the existing program. The Tupelo to Nashville route carried less than 10,000 passengers in 2017. See Dennis Seid, "Jet Service in Tupelo Anticipated to Begin in April," *Northeast Mississippi Daily Journal*, October 11, 2018. The route carried only about 3,000 passengers in 2015. See "OUR OPINION: Sky's the Limit for Commercial Air Service in Tupelo," *Daily Journal*, March 22, 2018.

cutting-edge regional air service. Firms and cities could collaborate in order to develop business plans for shuttle flights that fit the existing purposes and funding of the Alternate Essential Air Service Program.

c. Test the Corridor Traffic-Management Model and Market Assignment of Regional Routes

Third, the FAA should expand the FAA's newly proposed corridor-based traffic management system for advanced air mobility aircraft (which is typically viewed as urban trips) to include regional private aviation. In summer 2020, the FAA released a novel policy document proposing the demarcation of aerial corridors for advanced air mobility.[111] This document represents a policy innovation that would safely separate new aircraft from traditional manned aircraft and would also allow development of a UTM system. The UTM system would allow safe air traffic management without burdening traditional air traffic control with managing hundreds of thousands of new eVTOL, urban air mobility, and small-drone flights. Graboyes, Bryan, and Coglianese[112] and Graboyes and Skorup[113] discuss airspace architecture with respect to UTM systems.

The corridor system is an encouraging proposal that recognizes that airspace design needs to change in light of urban air mobility and drone technology. The FAA should consider expanding that corridor-based system to much of the regional aviation system that we have described. The same principles apply to regional aviation as to urban air mobility: corridors keep new airspace users safely away from piloted aircraft and encourage the development of

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[111] FAA, *Urban Air Mobility (UAM) Concepts of Operations*.

[112] Darcy N. Bryan, John Coglianese, and Robert F. Graboyes, "Overcoming Technological and Policy Challenges to Medical Uses of Unmanned Aerial Vehicles" (Mercatus Research, Mercatus Center at George Mason University, Arlington, VA, January 2020).

[113] Robert F. Graboyes and Brent Skorup, "Medical Drones in the United States and a Survey of Technical and Policy Challenges" (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, February 2020).

private and federated air traffic control systems parallel to and supplementing the traditional air traffic control system. Furthermore, since the corridor model is intended not to require traditional air traffic control input, a corridor approach for urban and regional air mobility allows the costs of air traffic management to be privately internalized, not subsidized like current air traffic control for private aviation.

Finally, if the FAA does put forward a plan for corridor-based regional aviation, it should consider market disposition of those corridors[114] rather than delegate corridor-sharing to industry as currently proposed.[115] Namely, the FAA should consider a public auction or lease of corridors to operators, much as the government leases spectrum to telecommunications operators and leases offshore sites to wind energy and oil companies.[116] The benefit of market disposition is that it avoids undue first-mover benefits (otherwise, operators would be tempted to "route squat" on popular regional corridors).[117] Leases of aerial corridors can also be structured so that innovators in UTM or regional aviation can gain access to airspace, something that has proven difficult in traditional aviation.[118]

Conclusion

The Airline Deregulation Act of 1978—often touted as one of the greatest achievements of the Carter administration—greatly improved the efficiency of commercial aviation. The older,

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[114] See Graboyes and Skorup, "Medical Drones in the United States and a Survey of Technical and Policy Challenges."

[115] NASA researchers currently propose industry-led sharing of corridors: "Prioritization and sequencing models will have been developed based on fleet operator business models and the FAA-approved [community-based rules]. The specifics have been informed by research into the efficiency and impartiality of a variety of methods such as "first-come, first-served," aircraft performance-based, or based on the service being provided. ... Process and criteria are consensus-based and consider the needs of key stakeholders (federal, state and local agencies, airspace users, public, etc.) to ensure equitable service and safe operations." See NASA, *UAM Vision Concept of Operations (ConOps) UAM Maturity Level (UML) 4*, version 1.0, 2021.

[116] Brent Skorup, "Auctioning Airspace."

[117] Skorup, "Auctioning Airspace."

[118] Skorup, "Auctioning Airspace"; Graboyes and Skorup, "Medical Drones in the United States and a Survey of Technical and Policy Challenges."

highly regulated system of air routes gave way to a hub-and-spoke system heavily reliant on large airliners flying in and out of large airports. The result yielded a much more efficient system—at least for travelers flying long distances between larger cities. However, the hub-and-spoke system was quite inconvenient for those wishing to travel between smaller, nonhub communities. We have referred to this as the Nashville-to-Asheville problem, where the number of nodes in the journey can make regional travel by airplane slower—and less convenient—than traveling by automobile.

In the late 1990s, a new idea for structuring aviation emerged. This was Burt Rutan and Bruce Holmes's vision for a system of small airplanes flying to and from small airports on ad hoc schedules. Their idea was an airborne equivalent to today's UberPool carpooling service, but such a transition seemed unlikely in the years after Rutan and Holmes began disseminating their ideas. The hub-and-spoke system was well-entrenched, and the costs of shifting were great. Transition meant grounding or scrapping large numbers of airliners, cutting the customer base for hub-and-spoke airports, purchasing large numbers of small planes, staffing the small planes with pilots, and increasing the staffing of the ATC system. In the late 1990s, it was difficult to argue for an aviation system that looks like ridesharing in a world where ridesharing services like Uber and Lyft did not yet exist.

In 2021, things have changed considerably. The impetus for a Rutan-Holmes type of aviation system, at least for smaller routes, has increased significantly, and the costs of implementing such a system have dropped considerably. However, enabling the development of an aviation system that looks like ridesharing will require some policy actions.

First, the technologies required to implement such an airborne ridesharing system have advanced greatly since the late 1990s. Ridesharing services are now a worldwide phenomenon. The technology necessary for a passenger to schedule a ride and for an air carrier to locate,

reserve, and dispatch a plane is now well-established. The ridesharing technology employed by Uber, Lyft, and other services can be adapted to airborne ridesharing as well. Second, the arrival of cellular signal access in small places means the prospective passenger's communications with the air carrier and ground transportation can be far more reliable than was the case 20 years ago; expanded broadband will improve the situation even more in the coming years. Third, there have been changes in aviation design, and more changes are coming.

On the demand side as well, the impetus for shifting to a Rutan-Holmes system prior to the pandemic was also increasing. There was already something of a migration out of big cities and into smaller towns and rural areas, as remote work lessened the professional reasons to remain in big cities. And many of those moving to smaller places have high-paying jobs, a taste for travel, and impatience with time-consuming processes.

Then, along came the COVID-19 pandemic, which accelerated the potential increase in demand for a Rutan-Holmes aviation system for smaller places. For some, the pandemic made big cities even less appealing in the long run. The pandemic wiped out or diminished the appeal of some big-city amenities. The need to work in a big city decreased markedly as businesses shifted to a heavier reliance on remote workers. Just a few years earlier, the lack of broadband would have made much of today's remote work untenable.

In the years soon after Rutan and Holmes shared their vision, the prospect of near-term transition was unlikely, in part because the hub-and-spoke routes were profitable and opposition to tampering with that status quo would have run high. When the pandemic hit, airlines massively slashed their flights, and the system is far from the level of activity that existed in late 2019. While airliners have excellent air purification systems and many passengers will have been vaccinated, there is still some risk of exposure to COVID on a plane, with many unknowns about future variants. Similarly, the airport and ground transportation present risks of COVID infection.

Flight protocols will include a long list of annoyances. Temperature checks, quarantines before and after the trip, and mask wearing throughout the flight make air travel a less pleasant activity. The effect may be to render some previously profitable hub-and-spoke routes unprofitable.

While much of this is conjectural, it has at least made the idea of a small-plane/small-airport system seem more plausible. But implementing such a system will require some public policy actions. It is important to know which small airports might be available for such a system and how much it would cost to prepare those airports for greater use. It is important to consider whether any changes in airspace architecture are needed. It is important to know where broadband is needed to operate such a system efficiently.

To summarize, a great deal of travel—and desired travel—in the United States is between localities a few hundred miles apart. Some travelers do these trips by air but endure considerable time in ground transportation, in airports, and on multiple-leg flights. Often the inconvenience of such conditions—and risk of missed connections—sends the traveler to drive via automobile, and, no doubt, many would-be travelers simply do not travel because the inconvenience and risk exceed the value of the trip. Planepooling—the NASA/FAA, Rutan-Holmes vision—offers a potential solution in the case of such short hops.

Since Rutan and Holmes introduced this vision in 1997, many things have changed. Small-aircraft technology, e-commerce, and ridesharing technologies have all advanced tremendously. The demographic out-migration from hub cities to smaller places has shifted current demand and potential demand for short-hop travel. The COVID-19 pandemic and its lingering aftershocks reaffirm the desirability of such alternatives to large flights.

Widespread implementation of planepooling, however, requires action at the federal, state, and local levels—as well as in the private sector. Localities must assess the feasibility of planepooling at the general aviation airports—and the need to upgrade some such facilities.