FAA AEROSPACE FORECAST

Fiscal Years 2023–2043

Federal Aviation Administration

Table of Contents

Forecast Highlights (2023–2043) 1
Review of 2022 5
Glossary of Acronyms 7
Acknowledgements 9
FAA Aerospace Forecasts 10
Economic Environment 11
U.S. Airlines 13
Domestic Market 13
International Market 18
System 23
Cargo 24
General Aviation 26
FAA Operations 32
U.S. Commercial Aircraft Fleet 35
Commercial Space 37
Regulatory Safety Oversight Activities of FAA 38
FAA's Launch and Reentry Operations Forecast 40
Additional Factors Affecting Forecast Accuracy 42
Unmanned Aircraft System and Advance Air Mobility 44
New Entrants: Analysis and Forecasts 44
Trends in Recreational/Model Aircraft New Registration 45
The Recreational UAS Safety Test (TRUST) 56
Trends in Commercial/Non-Model Aircraft and Forecasts Using Registrations vs. Effective/Active Fleet 57
2022 Survey and Preliminary Results 69
Remote Pilot Forecast 78
COVID-19 and Its Impact on sUAS 81
Large UAS 82
UAS Imports: Preliminary Analysis of Data 86
Advance Air Mobility 94
Forecast Uncertainties 114
Appendix A: Alternative Forecast Scenarios 119
Scenario Assumptions 119
Alternative Forecasts 123
Enplanements 123
Revenue Passenger Miles 124

Available Seat Miles 124
Load Factor 125
Yield 126
Appendix B: Forecast Tables 131

Forecast Highlights (2023–2043)

Since its deregulation in 1978 and the great recession of 2007-09, the U.S. commercial air carrier industry experienced a series of boom-to-bust cycles. The volatility that was associated with these cycles was thought by many to be a structural feature of an industry that was capital intensive but cash poor. However, the great recession of 2007-09 marked a fundamental change in the operations and finances of U.S Airlines. Since the end of the recession in 2009 through 2019, U.S. airlines revamped their business models to minimize losses by lowering operating costs, eliminating unprofitable routes, and grounding older, less fuel-efficient aircraft. To increase operating revenues, carriers initiated new services that customers were willing to purchase and started charging separately for services that were historically bundled in the price of a ticket. The industry experienced an unprecedented period of consolidation with three major mergers in five years. The results of these efforts were impressive: 2019 marked the eleventh consecutive year of profitability for the U.S. airline industry.

The outbreak of the COVID-19 pandemic in 2020, however, brought a rapid and cataclysmic end to those boom years. Airline activity and profitability tumbled almost overnight and without the financial and competitive strength built up during the boom, airlines would have faced even greater challenges. As it was, they were able to slash capacity and costs, and then, relying on their balance sheets, credit ratings and value inherent in their brands, to raise capital through borrowing and restructuring fleets allowing them to withstand the period of losses. Although several small regional carriers ceased operations in 2020, no mainline carriers did. Cargo activity was one of few bright spots as it surged, boosted by consumers purchasing goods to enhance time spent at home as necessitated by the pandemic, and by surface transportation disruptions caused by worker shortages due to COVID-19 illnesses.

Since 2020, conditions and the outlook have brightened considerably. As vaccines were introduced and local and international travel restrictions were lifted, leisure travel rebounded. Initially concentrated in outdoor recreation spots, whether beach or mountain, the recovery in leisure demand spread first to domestic destinations in 2021 and then expanded to many traditional international vacation destinations and by the summer of 2022, most carriers were reporting leisure demand was exceeding pre-pandemic levels. A rebound in business travel, which had been severely curtailed with the onset of the pandemic, lagged that of leisure demand. However by the end of 2022, U.S. airlines were reporting that business demand had recovered to 70-80% of pre-pandemic levels. Higher fares accompanied the strong rebound in leisure demand leading to positive financial results. For all of CY 2022, the top nine U.S. passenger carriers posted operating profits of $7.8 billion and net profits of $1.8 billion.

The business modifications necessitated by the downturn will shape the industry for years to come, long after the recovery is complete. Primarily, airlines will be smaller having retired aircraft and encouraged voluntary employee separations. Fleets, however, become younger and more fuel-efficient as retirements targeted the oldest and the least efficient aircraft. Although U.S. airlines carry high levels of debt, it is unclear to what extent capital spending and investment will be restrained, as evidenced by United's massive wide-body order for 787's in December 2022. And even the unbundling of services took a small step backwards as carriers eliminated change fees for all but Basic Economy tickets.

In the medium-term, airlines will be focused on trying to foretell the recovery in demand and position themselves to meet it. To date, that demand recovery has been extremely uneven across markets and population segments, driven by COVID-19 case counts, vaccinations, governmental restrictions and the degree of pent-up demand experienced by consumers and businesses. While leisure traffic has led the recovery, business travel is expected to build on the gains logged in 2022. International activity in some regions has lagged domestic due in part to individual country policies on lifting travel restrictions and will continue to lag over the next few years.

Long-term, the strengths and capabilities developed over during decade between the end of the great recession and the onset of COVID-19 will become evident again. There is confidence that U.S. airlines have finally transformed from a capital intensive, highly cyclical industry to an industry that can generate solid returns on capital and sustained profits.

Fundamentally, over the long-term, aviation demand is driven by economic activity, and a growing U.S. and world economy provides the basis for aviation to grow. The 2023 FAA forecast calls for U.S. carrier domestic passenger growth over the next 20 years to average 2.7 percent per year. This average, however, includes robust growth in 2023, as activity returns to pre-pandemic levels. Following the recovery period, trend rates resume with average growth through the end of the forecast of 2.8 percent. Domestic passengers are forecast to be within 1 percent, on an annual basis, of 2019 levels in 2023.

After averaging $55 per barrel over the five years ending in 2021, oil prices surged to $93 per barrel with the Russian invasion of Ukraine in 2022. Prices are forecast to ease somewhat over the next two years before climbing slowly to reach $113 per barrel at the end of the forecast period.

Just as U.S. economic activity drives domestic demand for air transport, foreign economic activity affects international travel demand. As global economies were recovering from the pandemic in 2022, the demand imbalances and Russia's invasion of Ukraine sent consumer prices soaring. Central banks moved to restrain inflation by raising interest rates and slowing demand which consequently curtailed GDP growth as well as price increases. In 2023, GDP is expected to slow further to the extent that the U.S. enters a mild recession while Europe sees a sharper downturn. Latin American growth remains solidly positive and China's economy, which suffered from stringent COVID-19 policies in 2022, rebounds in 2023 supporting the region. Global growth returns close to trend rates in 2024 although some individual countries take longer.

System traffic in revenue passenger miles (RPMs) is projected to increase by 3.2 percent a year between 2023 and 2043. Domestic RPMs are forecast to grow 3.0 percent a year while International RPMs are forecast to grow faster at 3.7 percent a year, largely due to the steep declines in 2020 and 2021 that brought RPM to just 31 percent of 2019's level – about half that of domestic RPM. Thus, these figures are boosted by several years of high growth rates during the recovery after which the annual rates return to more moderate long-term trends. The strong growth rates propel system RPM, on an annual basis, to exceed 2019 levels in 2024, with domestic RPM returning a year earlier while international RPM also recovering in 2024. System capacity as measured by available seat miles (ASMs) is forecast to grow somewhat slower than RPM during the recovery period as airlines seek to restore load factors but, subsequently, ASM grow in line with the increases in demand.

After U.S. carriers posted an unexpected profit in CY 2022, the FAA expects U.S. carriers to remain profitable over the next few years as rising demand -- despite higher fares -- more than offsets higher costs for labor and fuel. As carriers return to levels of capacity consistent with their fixed costs, shed excess debt, and yields stabilize, consistent profitability should continue. Over the long term, we see a competitive and profitable aviation industry characterized by increasing demand for air travel and airfares growing more slowly than overall inflation, reflecting growing U.S. and global economies.

The general aviation (GA) sector was less affected by the COVID-19 crisis than the airlines and recovered faster. Private aviation became an attractive substitute for wealthier individuals who could afford to pay during the heaviest times of the pandemic. Even though there are recent indicators that with airlines increasing frequency of their scheduled flights, some reversal in this trend is expected, many have continued to fly privately. At the lower end of the industry, new comers to private flying included student, private and commercial pilots, joining the existing GA pilot population. The long-term outlook for general aviation thus is promising, as growth at the higher-end offsets continuing retirements at the traditional low end, mostly piston-powered part of the sector. The active GA fleet is forecast to increase by 3.5 percent between 2023 and 2043, after declining slightly in 2022 from the year before. The turbine aircraft fleet, including rotorcraft, did not experience a decline between 2019 and 2021, and is estimated to have shown a small increase between 2021 and 2022. The total of piston fleet (single and multi-engine pistons, light-sport aircraft, and piston rotorcraft) declined by 2.0 percent between 2019 and 2021 and is estimated to have fallen by an additional 0.7 percent in 2022. While steady growth in both GDP and corporate profits results in continued growth of the turbine and rotorcraft fleets, the largest segment of the fleet – fixed wing piston aircraft will continue to shrink over the forecast period, just to be offset by the growing turbine fleet. Despite the minimal growth of the active GA fleet between 2021 and 2043, the number of GA hours flown is projected to increase by 16.6 percent from 2021 to 2043 (an average of 0.7 percent per year), as growth in turbine, rotorcraft, and experimental hours more than offset a decline in fixed wing piston hours.

With robust air travel demand growth between 2023 and 2025, we expect increased activity growth that has the potential to increase controller workload. The recovery in U.S. airline activity from the COVID downturn is the primary driver. The U.S. commercial aviation sector was hit by the pandemic much harder than the non-commercial sector. Operations at FAA and Contract Towers return to pre-COVID levels in 2023, led by strong growth in commercial operations. In particular, large and medium hubs will continue to see faster increases than small and non-hub airports, largely due to the commercial nature of their operations. Over the entire forecast period, operations at FAA and contract towers are forecast to grow 1.2 percent a year with commercial activity growing at approximately four times the rate of non-commercial (general aviation and military) activity.

Commercial Space launch activity has been steadily growing over the past 5 years. FY2022 actuals were the highest in U.S. history at 74, accounting for 13% of the activity since 1989.

FAA is forecasting launch and re-entry activity to increase from a low-high range of 61-94 in FY2023 to a low-high range of 123-288 by FY2027. Much of this increase is attributable to the lineup of reusable vehicles and the expectation for increased human space exploration.

Drones have been experiencing healthy growth in the United States and around the world over the past decade. The last few years have been no exception despite the profound impact of COVID-19 on the overall economy. The introduction of drones in the NAS has opened up numerous possibilities, especially from a commercial perspective. That introduction has also brought operational challenges including safe and secure integration of drones into the NAS. Despite these challenges, the drone sector holds enormous promise; potential uses range from individuals flying solely for recreational purposes to individual businesses carrying out focused missions to large companies delivering commercial packages and delivering medical supplies. Public service uses, such as conducting search and rescue support missions following natural disasters, are proving promising as well. The FAA forecasts that the recreational small drone fleet will likely (i.e., base scenario) attain its peak over the next 5 years, from the present 1.69 million units now to approximately 1.82 million units by 2027 thus attaining cumulative annual growth rate of 1.6% during 2022-2027. Based on registration data, the size of the commercial drone fleet (> 0.5 lbs up to 55 lbs) came in around 727,000 aircraft by the end of 2022. As the present base (i.e., the cumulative total) increases, the FAA anticipates the growth rate of the sector will slow down over time, the FAA forecasts that the commercial drone fleet will likely (i.e., base scenario) be at around 955,000 by 2027.

Another sector showing enormous promise is Advanced Air Mobility (AAM). Based on the research performed by numerous others, the FAA believes that AAM will likely enter into services (EIS) sometime around 2025-2026. Starting from limited services to initial launch cities noted earlier, services will be experimental, slow and likely gain a gradual trajectory of growth until 2030. We expect that initial 5 years or so will be required to resolve many outstanding issues including establishing solid AAM business cases. Depending upon the sector's resolving the outstanding issues, this will be followed by a moderate service trajectory during 2030-2040. Beyond that period, we anticipate a sustainable, mature sector on a longer-term growth trajectory

Review of 2022

Following two difficult years of coping with COVID-19 and its impacts, 2022 brought significant improvement and the beginning of the shift from a pandemic to an endemic phase. The pandemic's consequences persisted, however, as the demand imbalances and supply chain disruptions continued to boost inflation. Russia's invasion of Ukraine added to the pressure with higher oil and other commodity prices while depressing consumer confidence. As central banks raised interest rates to combat inflation, and fiscal support from the pandemic years waned, economic activity slowed. However, consumers also began normalizing spending with a shift out of goods and into services, including air transport. Although air cargo flattened out, passenger air travel surged, and operations rose for both the air carrier and general aviation segments. UAS activity grew solidly and commercial space launches surged in 2022, both of which had expanded in 2021.

U.S. commercial passenger activity started the year well above the level in 2021 and generally saw upward progress throughout the year. TSA checkpoint throughput increased from about 15 percent below 2019's level to about 5 percent below by the end of the year. The main source of strength throughout the year was from leisure travelers, with a surge in the summer that included a pick-up in the Atlantic region, adding it to the domestic and Latin destinations that were closing in on 2019 levels. In the business segment, activity grew somewhat although not to the same extent as in the leisure segment as many employees remained on work-from-home status and meetings, conferences and trainings were either conducted virtually or forgone.

Airlines sought to respond to the sudden increase in demand and worked to match capacity with changes in timing, markets and segments. According to the Bureau of Transportation Statistics (BTS), airline employment rose throughout the year with average increase of nearly 5,000 jobs per month. At year end, employment was 35,000 higher than in 2019. However, new hires needed time to ramp up and many carriers were restrained by training bottlenecks as well as productivity reductions due to the large number of junior staff. Further constraining their ability to boost capacity were aircraft delivery delays, as well as staffing shortages at airports and some ATC locations.

In FY2022, system traffic as measured by revenue passenger miles (RPMs) grew 60.1 percent from the previous year while system enplanements rose 48.9 percent. Domestic RPMs were 46.2 percent higher while enplanements were up 45.5 percent. After falling for two consecutive years, international RPMs more than doubled, surging by 132.3 percent while enplanements rose by 84.0 percent – the relative difference due to the pickup in long-haul Atlantic markets. Hampered by constraints, system ASM expanded by 34.0 percent with domestic ASM growing 26.7 percent and international up 62.2 percent. The disparate growth rates pushed the system-wide load factor up 13.3 percentage points to 81.8 percent.

System nominal yields rose sharply in 2022, up 30.8 percent after falling during each of the previous two years. Several factors contributed, including on the supply side, a spike in fuel and labor costs, as well as constrained production. On the demand side, consumers were eager to travel and, in aggregate, tolerated the fare increases.

With the surge in activity during the year, financial results improved as well. Data for FY2022 shows that the reporting passenger carriers had a combined operating profit of $3.4 billion compared to an average profit over the five years ending in FY2019 of $22.1 billion. As with operations, profitability improved markedly during the second half of the year that saw two consecutive quarterly profits, the first profits since the outbreak of the pandemic. Those two quarter, $4.7 billion each, brought the year into the black.

The general aviation industry almost completely recovered from its decline in 2020 with an increase of 17.0 percent in deliveries of U.S. manufactured aircraft between 2021 and 2022 (10.3 above 2019 levels), with pistons up by 15.4 percent and turbines up by 18.8 percent. Global billings increased by 5.9 percent to $22.9 billion (still down by 2.8 percent from 2019 levels – statistics for U.S. billings were not available as of the publication date of this report).

Total operations in 2022 and FAA and contract towers increased by 10.2 percent compared to 2021 (down by 1.3 percent from 2019). Air carrier activity increased by 24.0 percent, while air taxi operations were up 10.8 percent. General aviation activity increased by 5.2 percent (the only segment with activity levels higher than 2019) and military activity was down by 4.7 percent. Activity at large and medium hubs rose by 24.2 percent and 14.9 percent, respectively, while small and non-hub airport activity rose by 5.6 percent in 2022 compared to the prior year.

Glossary of Acronyms

Acronym	Term
AAM	Advanced Air Mobility
ANG	FAA Office of NextGen
ARP	FAA Office of Airports
ASMs	Available Seat Miles
AST	FAA Office of Commercial Space Transportation
ATO	FAA Air Traffic Organization
ATP	Air Transport Pilot
AUVSI	Association for Unmanned Vehicle Systems International
BVLOS	Beyond Visual Line of Sight
CAPS	COA Application Processing System
CBP	Customs and Border Patrol
CFR	Code of Federal Regulations
COAs	Certification of Authorizations
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRS	Commercial Resupply Services
CY	Calendar Year
DARPA	Defense Advanced Research Projects Agency
DHS	Department of Homeland Security
DoD	Department of Defense
DoE	Department of Energy
DoI	Department of Interior
eVTOL	Electric Vertical Take-off and Landing
FAA	Federal Aviation Administration
FY	Fiscal Year
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GC	Grand Challenge
GDP	Gross Domestic Product
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMF	International Monetary Fund
ISS	International Space Station
LAANC	Low Altitude Authorization and Notification Capability
LCC	Low Cost Carriers
LSA	Light Sport Aircraft
lUAS	Large Unmanned Aircraft System(s)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorization Act
NOTAM	Notices to Airmen
NPRM	Notice of Public Proposed Rulemaking
PCE	Personal Consumption Expenditure
PDARS	Performance Data Analysis and Reporting Systems
RAC	Refiners' Acquisition Cost
RLV	Reusable Launch Vehicle
RP	Remote Pilot

RPA	Remote Pilot Authorization
RPMs	Revenue Passenger Miles
RTMs	Revenue Ton Miles
sUAS	Small Unmanned Aircraft System(s)
SpaceX	Space Exploration Technologies Corp.
TRACON	Terminal Radar Approach Control
TRB	Transportation Research Board
TSA	Transportation Security Administration
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System(s)
UASFM	UAS facility maps
USD	United States Dollar
VFR	Visual Flight Rules

Acknowledgements

This document was prepared by the Forecast and Performance Analysis Division (APO-100), Office of Aviation Policy and Plans, under the direction of Roger Schaufele and Michael Lukacs.

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APO Websites

- Forecasts and Statistical publications — http://www.faa.gov/data_research/aviation_data_statistics/
- APO databases — http://aspm.faa.gov

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FAA Aerospace Forecasts
Fiscal Years 2023-2043

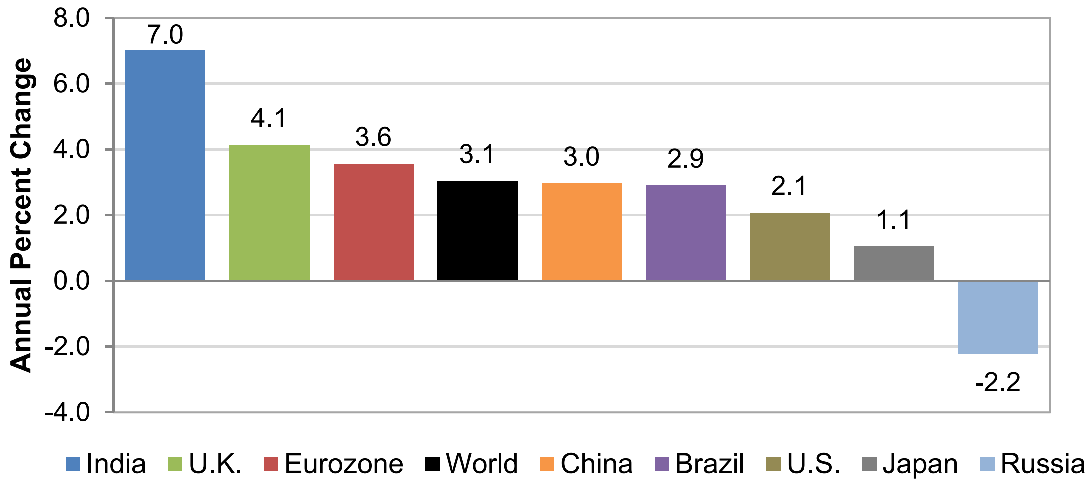
Economic Environment

In 2022, global real GDP expanded solidly as the economic recovery from the effects of the pandemic continued. After surging 6.1 percent in 2021, GDP rose by 3.1 percent in 2022, a rate similar to that over the decade prior to 2019. Despite these two years of strong growth, the level of GDP is not expected to return to its pre-pandemic path for several more years. After providing considerable fiscal and monetary stimulus during the pandemic, countries have turned their attention to controlling deficits and reining in inflation, both of which contribute to moderating GDP growth in the coming years.

In the U.S., real GDP growth slows from 2.1 percent in 2022 to 0.7 percent in 2023 as COVID-19 relief measures wear off, consumer spending normalizes and higher interest rates slow activity. Compared to the U.S., real GDP growth in the European Union plus U.K. was somewhat stronger in 2022 at 4.1 percent but slightly weaker at 0.3 percent in 2023. Aggressive deficit reduction efforts, high energy costs and interest rates all dampen growth in the near-term and combine with the area's lower trend rate. In Japan, border reopenings support exports, particularly to China, as well as inbound tourism that combine with expansionary fiscal policies to produce real GDP growth of 1.2 percent in both 2023 and 2024. Trend growth rates of under one percent return in the second half of the decade as the country's persistent problems of weak consumer spending, and population and demographic trends continue. Although China's growth remained positive through the pandemic, its zero-COVID policy resulted in real GDP growth of just 3.0 percent in 2022, very low for a country that averaged 7.7 percent in the decade ending in 2019. For the remainder of the 2020's, growth is expected to come in at about 5.0 percent weighed down by stalled economic and banking-sector reforms, and high rates of household savings.

In large emerging markets, Brazil's considerable fiscal stimulus was withdrawn in 2022, pulling growth down to 2.9 percent. Growth slows further to 1.7 percent in 2023 due to slowdowns in the U.S. and Europe that restrain exports, tourism and capital flows, as well as from high domestic inflation necessitating high interest rates. Russian growth has turned negative, however, due to Western sanctions. In 2022 it was estimated at -2.2 percent and -2.8 percent in 2023. Positive growth returns in 2024 but remains hampered by the E.U.'s shift to other fuel sources and the similar loss of markets for other exports, in addition to productivity losses due to the departure of Western companies and skilled professionals. India has seen strong support from the unwinding of pent-up domestic demand countered by slowing global growth that moderated exports, resulting in growth of 5.4 percent in 2023. In the medium-term its growth will be driven by favorable demographics including strong consumer spending from growing middle-income households, increasing contributions from the service sectors, and undeveloped natural resources.

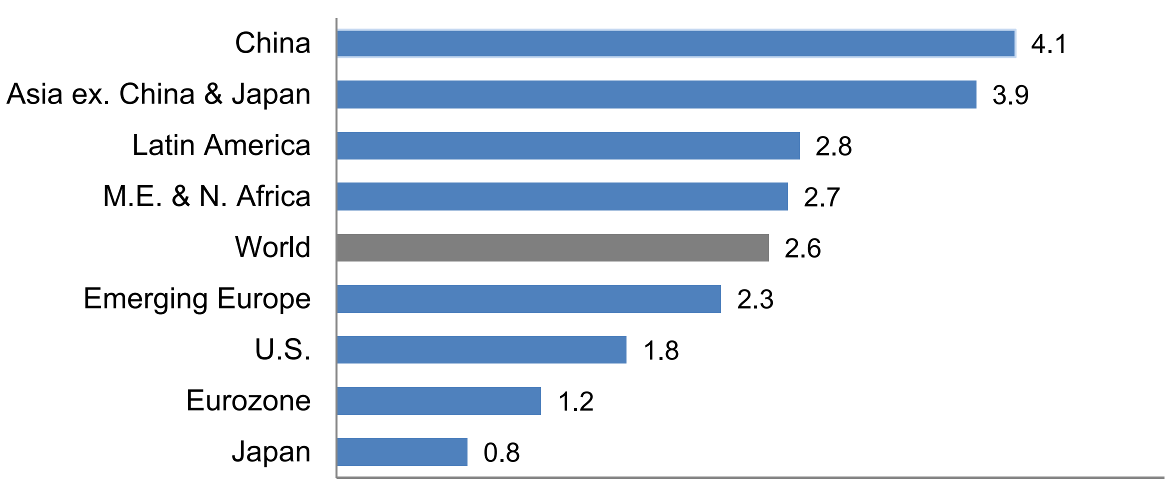
World Economic Growth in 2022



Source: IHS Markit

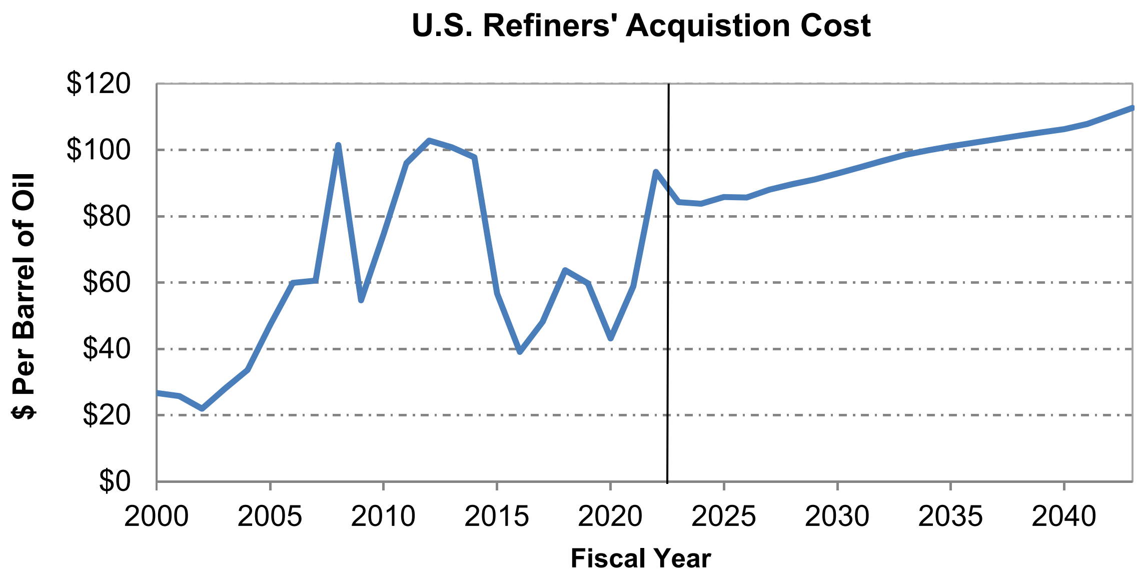
IHS Markit forecasts world real GDP to grow at 2.6 percent a year between 2023 and 2043. Emerging markets, at 3.8 percent a year, are forecast to grow above the global average but at lower rates than in the early 2000's. Asia (excluding Japan), led by India and China, is projected to have the fastest growth followed by Africa and Middle East, Latin America, and Eastern Europe. Growth in the more mature economies (1.5 percent a year) will be lower than the global trend with the fastest rates in the U.S. followed by Europe. Growth in Japan is forecast to be very slow at 0.8 percent a year reflecting deep structural issues associated with a shrinking and aging population.

Asia and Middle East/N. Africa Lead Global Economic Growth
(annual GDP percent growth 2023-2043)



Source: IHS Markit, Jan 2023 World Forecast

Oil spiked to $93 per barrel in 2022 in the wake of Russia's invasion of Ukraine. After receding slightly in 2023, prices remain stagnant for a few years before beginning to climb as economic activity accelerates. Over the long-run, IHS Markit expects the price of oil to increase due to growing global demand and higher costs of extraction. IHS Markit forecasts U.S. refiner's acquisition cost of crude to rise to $113 per barrel at the end of the forecast horizon.



Source: IHS Markit

U.S. Airlines

Domestic Market

Mainline and regional carriers[1] offer domestic and international passenger service between the U.S. and foreign destinations, although regional carrier international service is confined to the border markets in Canada, Mexico, and the Caribbean.

Over the coming years, the commercial air carrier industry will be focused on managing through the aftereffects of the pandemic. Although demand has been returning to 2019 levels, the progress has been unsteady and uneven across segments making it difficult to plan and manage capacity. Furthermore, carriers face numerous factors constraining their ability to add capacity back into networks – factors that will take years to resolve. As predictability returns and balance sheets strengthen, carriers will pay down debt burdens accumulated during the pandemic and transition to more traditional long-term business strategies.

While demand showed more predictability in 2022 than in the previous two years, its strength and characteristics were still not the

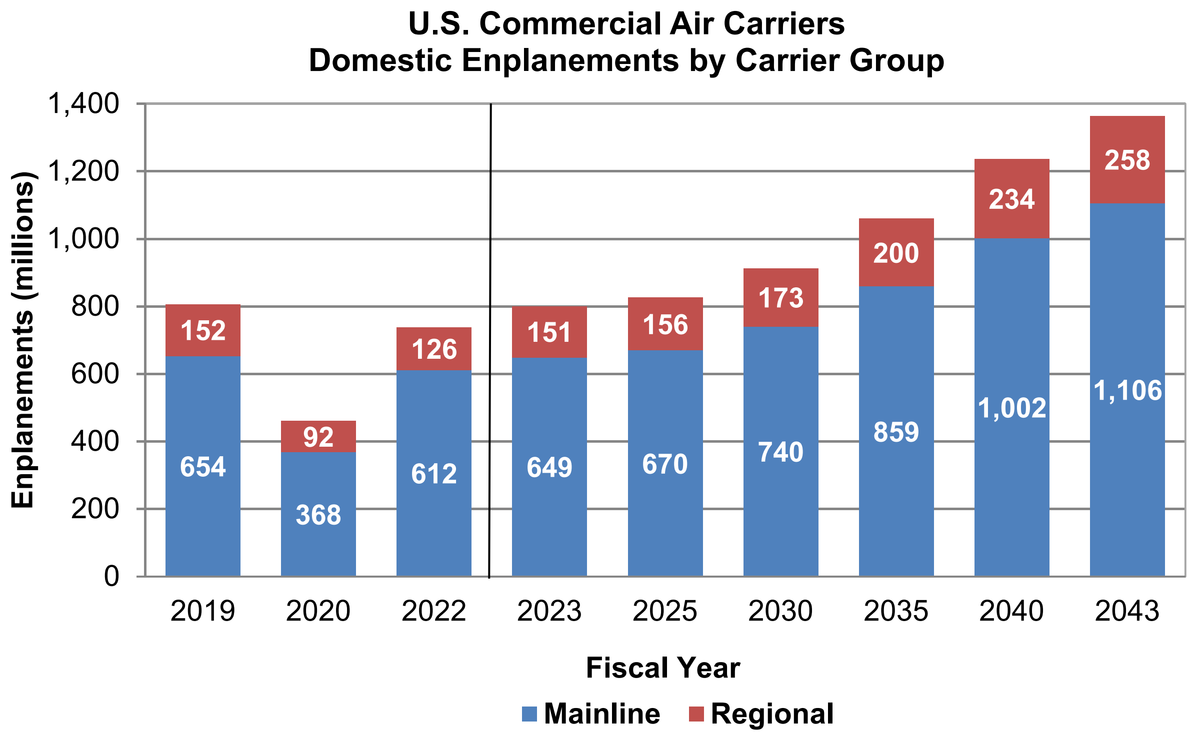
[1] Mainline carriers are defined as those providing service primarily via aircraft with 90 or more seats. Regionals are defined as those providing service primarily via aircraft with 89 or fewer seats and whose routes serve mainly as feeders to the mainline carriers.

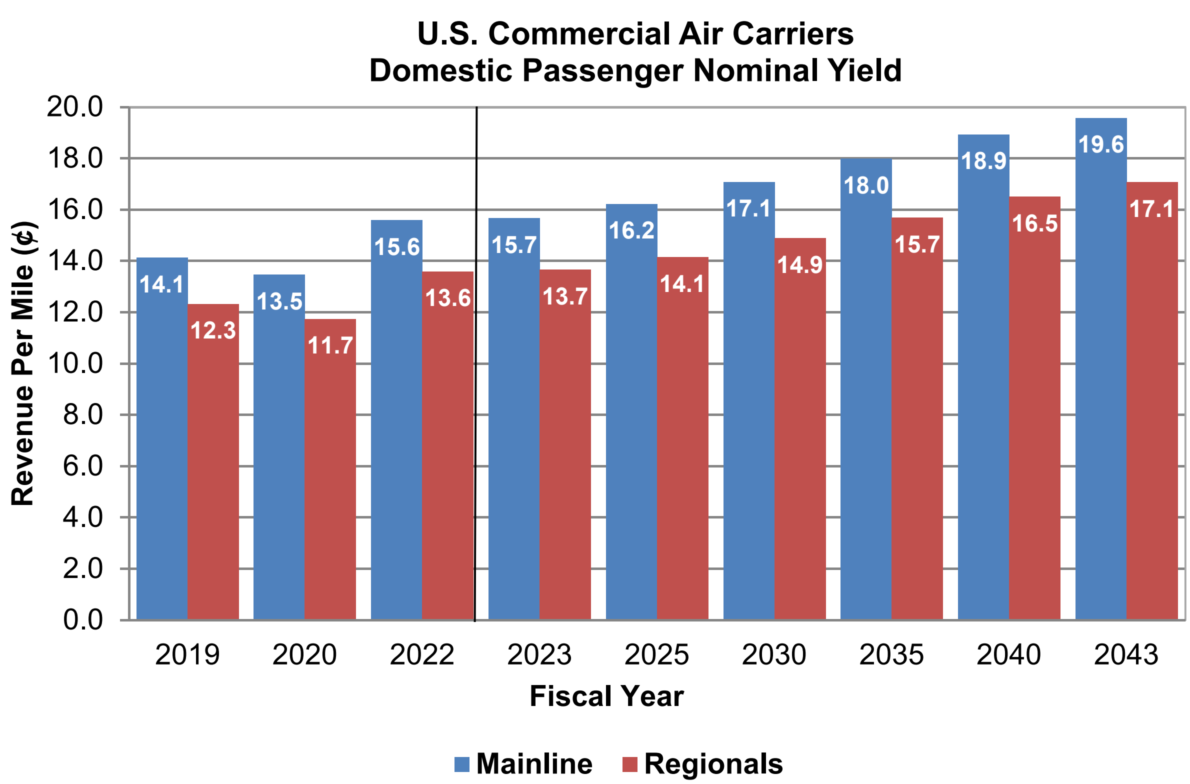
same as in the pre-pandemic environment and it may be years before it returns to that previous normal. Leisure traveler demand is expected to continue as the main driver while business trips remain well below prior levels and are growing only slowly. And although leisure travelers are demonstrating confidence by booking further out from departure, the day-of-week and seasonal patterns have been shifted by an increase in blended leisure and business trips. By geographic region, the altered balance between leisure and business has shifted demand towards medium-sized and sun-belt cities, and away from transcontinental routes and coastal destinations. Overall demand will return to 2019's level in 2023 but its characteristics will not be the same, complicating carrier's ability to capture it.

Air carriers' ability to manage capacity is further complicated by constraints that arose during the pandemic and that will take years to unwind. Hiring and training bottlenecks have left carriers, regionals especially, short staffed for pilots as well as maintenance crews. And even where staffing levels are above where they were in 2019, such as for gate and ramp agents, the large proportion of new hires has lowered productivity. The effects of supply chain disruptions linger, and combined with similar staffing issues, are hampering manufacturers' ability to deliver new aircraft creating years-long backlogs. Finally, under-staffing at a few ATC facilities is limiting the number of aircraft that can be handled in those places. These issues will all be slow to reverse and weigh on the forecast of capacity production for the next three to five years, or possibly longer.

Higher airfares have already resulted from increased labor expenses necessary to attract and retain workers and this elevated spending is expected to be permanent. Beyond that, the industry-wide damping of capacity relative to demand has allowed carriers to pass through other fare increases that are helping to begin paying down debt incurred during the pandemic. Until debt returns to more typical levels, it will act as an additional restraint on investment and expansion.

During the first years of the pandemic, regional carriers suffered very similar consequences of COVID-19 as did the mainline group. However, in 2022, regionals provided 9.3 percent of domestic capacity, down from 10.7 percent in 2019, a result of both the shift in demand and difficulty supplying capacity as flight crews moved up to higher paying mainline jobs. In terms of traffic, regionals saw similar declines, dropping to 8.9 percent of RPM in 2022 compared to 10.0 percent in 2019. The deviations in 2022 are expected to be temporary as travel patterns and airline operations continue the slow recovery to more normal conditions.


U.S. Commercial Air Carriers
Domestic Enplanements by Carrier Group
Enplanements (millions)
1,400
1,200
1,000
800
600
400
200
0
152
654
92
368
126
612
151
649
156
670
173
740
200
859
234
1,002
258
1,106
2019
2020
2022
2023
2025
2030
2035
2040
2043
Fiscal Year
Mainline
Regional


U.S. Commercial Air Carriers
Domestic Passenger Nominal Yield
Revenue Per Mile (¢)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
14.1
12.3
13.5
11.7
15.6
13.6
15.7
13.7
16.2
14.1
17.1
14.9
18.0
15.7
18.9
16.5
19.6
17.1
2019
2020
2022
2023
2025
2030
2035
2040
2043
Fiscal Year
Mainline
Regionals

The regionals have less leverage with the mainline carriers than they have had in the past as the mainline carriers have negotiated contracts that are more favorable for their operational and financial bottom lines. And as mainline carriers cut service to smaller cities over the past three years, it was the regional partners that were most affected. Furthermore, mainline carriers successfully reduced costs by offering voluntary retirements to flight crews but as activity picked up they drew replacements from the ranks of the regionals, exacerbating their pre-pandemic pilot shortages. As regional carriers recover and activity returns to 2019 levels, service to smaller cities is expected to return. Regional pilot shortages, however, are likely to persist through next year due to the time required for training and recruitment.

A trend for regionals that was largely unaffected by the pandemic is the longstanding increase in the number of seats per aircraft. This measure rose by more than 55 percent over the decade from 1997 to 2007 and although it slowed more recently to an increase of 17 percent in the ten years ending in 2019, that same pace generally continued in 2022. A consequence of this drive to replace 50 seat regional jets with more fuel-efficient 70 seat jets is that capital costs have increased. The move to the larger aircraft will prove beneficial in the future, however, since their unit costs are lower.

Mainline carriers have also been increasing the seats per aircraft flown although, unlike that for the regionals, the trend had been accelerating. From 1997-2007, mainline seats per aircraft expanded just one-half of one percent but from 2009-2019, the measure grew 10 percent. In 2022, mainline seats per aircraft bumped up to 12 percent over the decade as carriers flew some of their idle long-haul international aircraft on domestic routes.

Another continuing trend is that of ancillary revenues. Carriers generate ancillary revenues by selling products and services beyond that of an airplane ticket to customers. This includes the un-bundling of services previously included in the ticket price such as checked bags, on-board meals and seat selection, and by adding new services such as boarding priority and internet access. After posting record net profits in 2015, U.S. passenger carrier profits declined subsequently on rising fuel and labor costs, and flat yields, but were supported by ancillary revenues. Even in 2020 when profits turned to staggering losses, this remained a meaningful source of revenue for carriers.

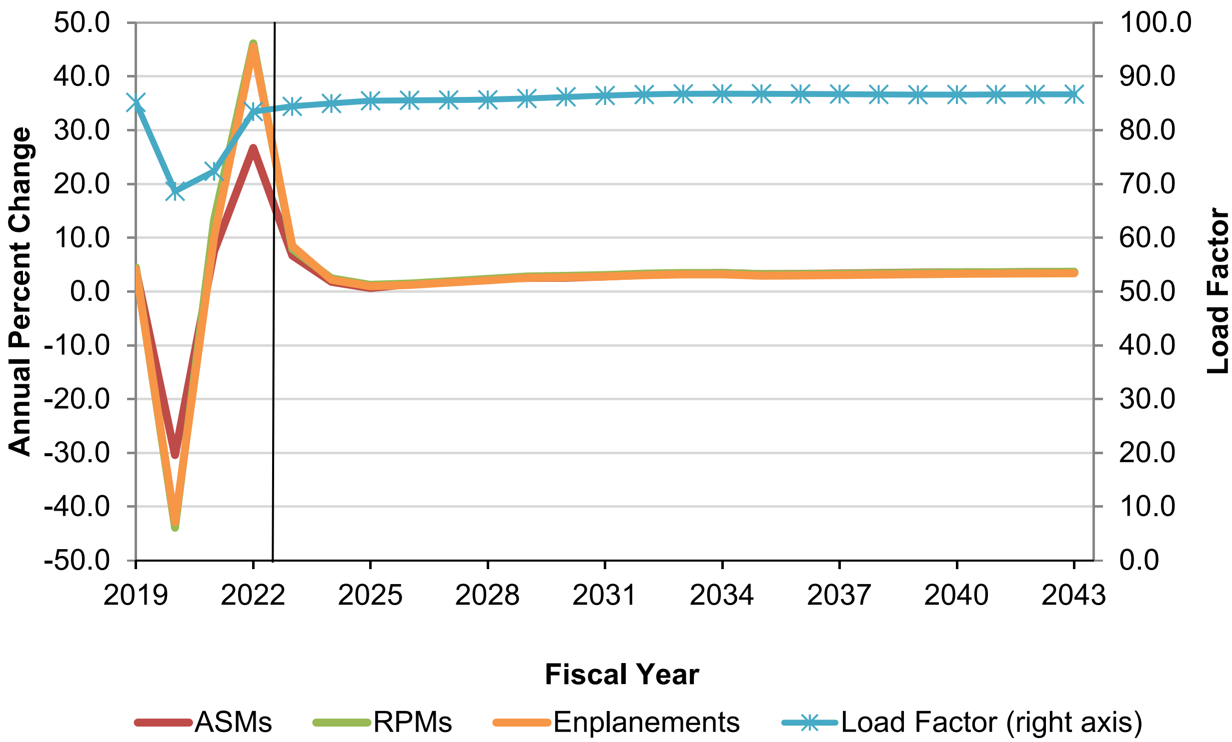
On the other hand, revenue management systems that have grown increasingly sophisticated in recent years became almost worthless in 2020. These systems enable carriers to price fares optimally for each day and time of flight, and to minimize foregone revenue. But, because they rely on historical data to make price and schedule predictions, the unprecedented nature of the collapse in 2020 meant they could provide little guidance and carriers were forced to assess market conditions without the benefit or precision of that quantitative analysis.

While revenue management systems will regain their important role once travel demand returns to more normal rhythms, one source of ancillary revenue, change fees, was broadly scrapped in 2020. As traveler plans were forced to change due to COVID-19-related restrictions, airlines began dropping fees for itinerary changes in many ticket classes. As a share of total passenger revenue, cancellation fees dropped from about 2 percent in FY2019 and the years prior to under

1 percent in FY2022. Some airlines have stated that the elimination of change fees is a permanent move and won't be reversed with the end of the pandemic. In contrast, baggage fees seem unlikely to be rescinded as their share rose from 4.0 percent to 4.6 percent in FY2022.

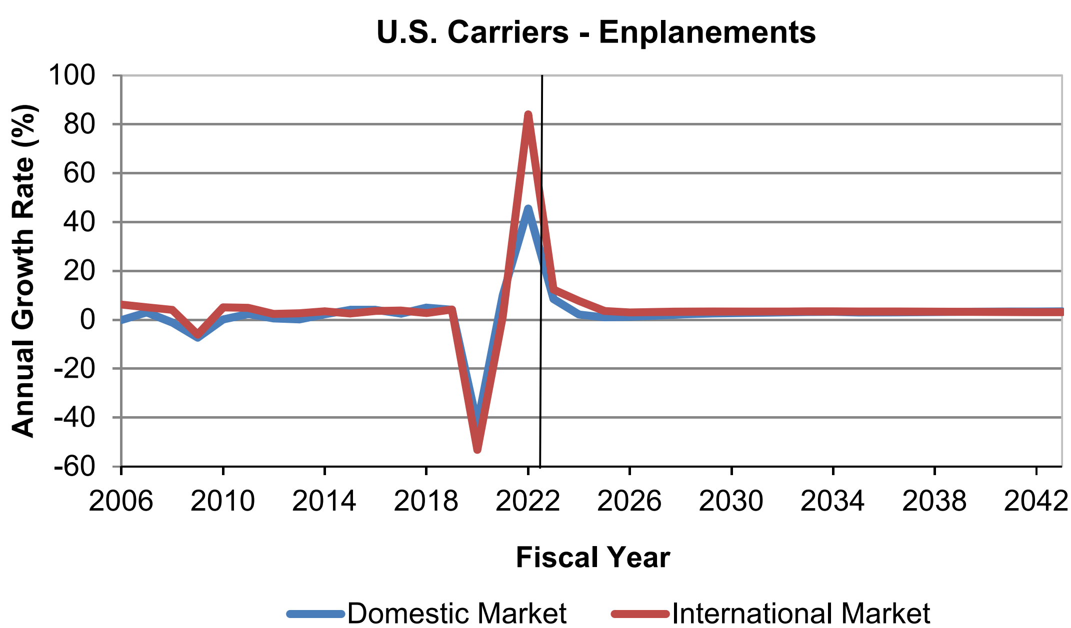
Other methods of segmenting passengers into more discreet cost categories based on comfort amenities like seat pitch, leg room, and access to social media and power outlets were unaffected by the pandemic. The offering of Basic Economy fares has been part of an effort by network carriers to protect market share in response to the rapid growth low cost carriers (LCC) have achieved in recent years. In 2019, mainline enplanements had increased almost 23 percent since 2007 but low cost carrier enplanements grew by 39 percent. RPM over the same period show a similar pattern with mainline RPMs up almost 27 percent and LCC RPM fully 48 percent higher. These longer term trends were interrupted in 2020 with enplanements and RPM dropping across both mainline and LCC carriers to about 55 percent of 2019's levels. However, by 2022 the strength of LCC's became apparent again as their enplanements and RPM had recovered to about 97 percent of 2019 levels while mainline traffic lagged slightly at about 92 percent.

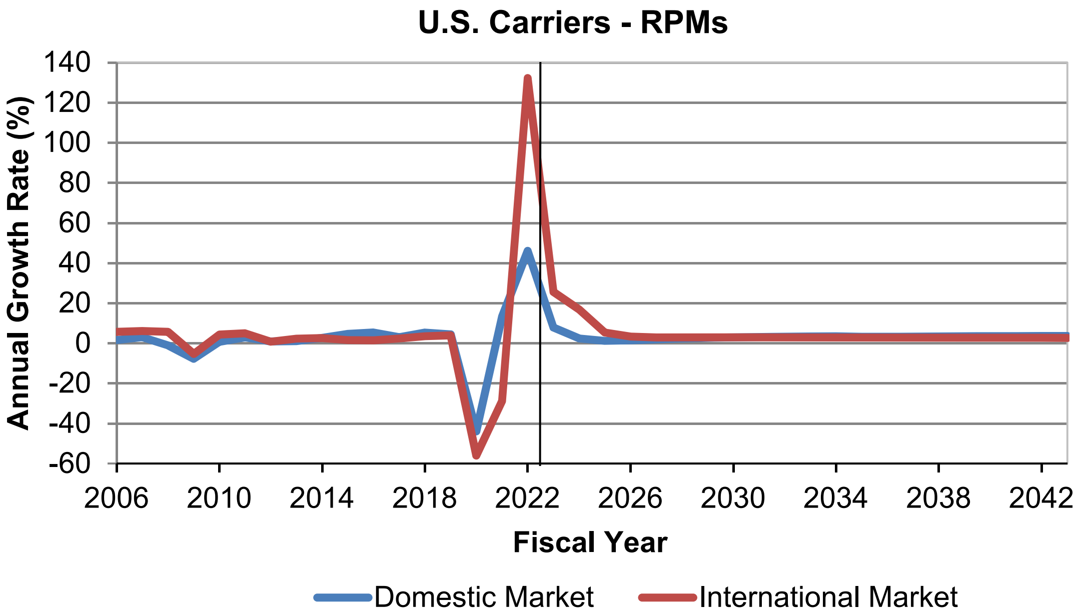
U.S. Commercial Air Carriers
Domestic Market

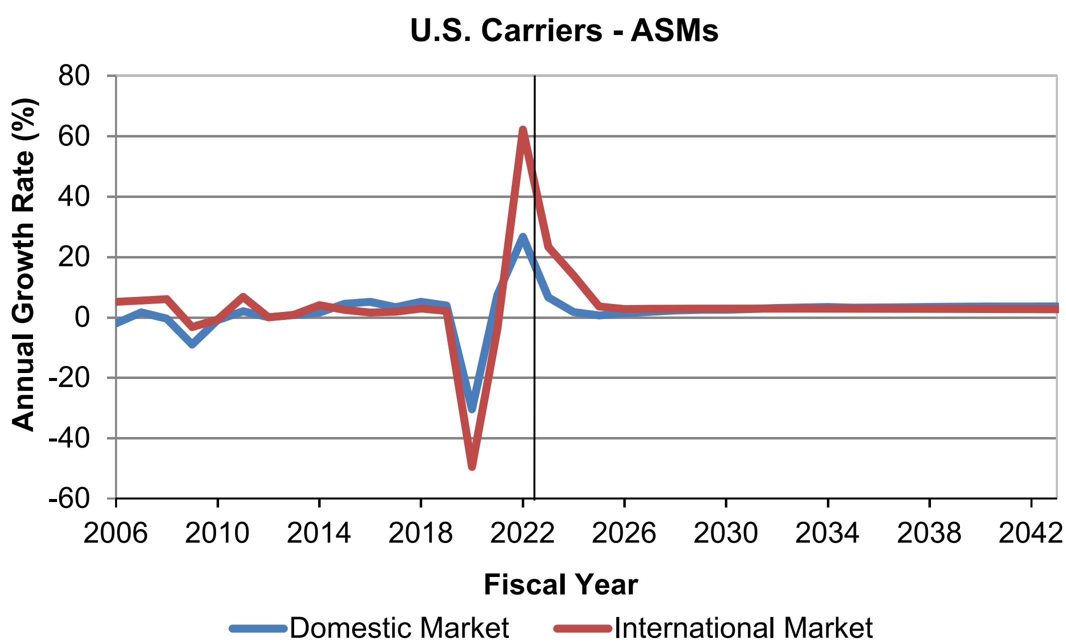


International Market

Over most of the past decade, the international market has been the growth segment for U.S. carriers when compared to the mature U.S. domestic market. In 2015 and 2016, growth in the domestic market surged, outpacing international markets. However, in 2017 enplanement growth in international markets exceeded that in domestic markets, only to be reversed again in 2018 and 2019. That relative strength of domestic activity compared to international intensified during the downturn in 2020 and subsequent recovery. In 2022, domestic enplanements had returned to 92 percent of 2019's level after being at just 63 percent a year earlier, while international enplanements showed even stronger improvement, reaching 87 percent, compared to 47 percent in the previous year. International travel has been particularly impacted by border closings, quarantine requirements and other travel restrictions, as well as the uncertainty of when requirements might change. The fall off of business travel also contributed to the decline and slower recovery, even as leisure travel supported domestic markets. International travel is expected to show further gains in 2023 as the last restrictions are lifted and business travel continues its recovery.



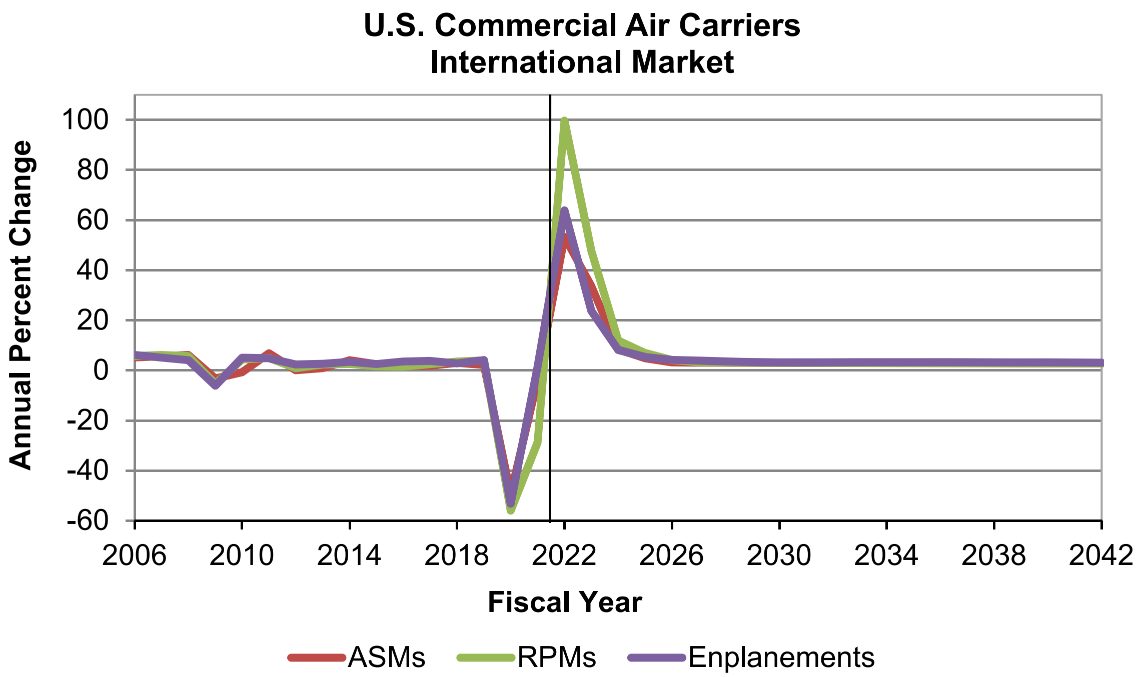




The next two years of the international recovery will see some strong growth rates as activity levels come off a low base but these will return to more typical rates once levels approach 2019 values expected in 2024. For FY2023 and FY2024, the average annual growth rate for international ASM is forecast to be 19 percent, RPM are projected at 21 percent and enplanements at 10 percent as aggregate trip lengths grow due to increasing Atlantic and Pacific activity. From FY2024-2043, annual growth for ASM and RPM are forecast to grow at 2.9 and 3.0 percent, respectively, while enplanements will grow at a rate of 3.3 percent. Taking these two periods as a whole gives annual growth rates from FY 2022-2043 for ASM, RPM and enplanements of 4.3, 4.6, and 3.9 percent, respectively.

Load factors recovered sharply in 2022, reaching 77 percent, well above the low of 54 percent in the previous year but still below 2019's 83 percent. Load factors are projected to rise throughout the remainder of the decade before plateauing at 82 percent through the end of the forecast.

In the long-run, growth of major global economies will slow from the above-trend rates of recent, pre-pandemic years. Several moderating factors are at work, including high inflation and interest rates, reduced global trade, and political stresses. The European and Japanese economies are generally seeing slow but positive growth, in part due to weak trade with Asia. Overall, global conditions appear set to return to a stable path once the economic environment improves with looser financial conditions, diminished risk of recession, and confidence that COVID-19 has become endemic. Rising oil prices, however, will create some drag on this otherwise supportive environment for air travel demand.



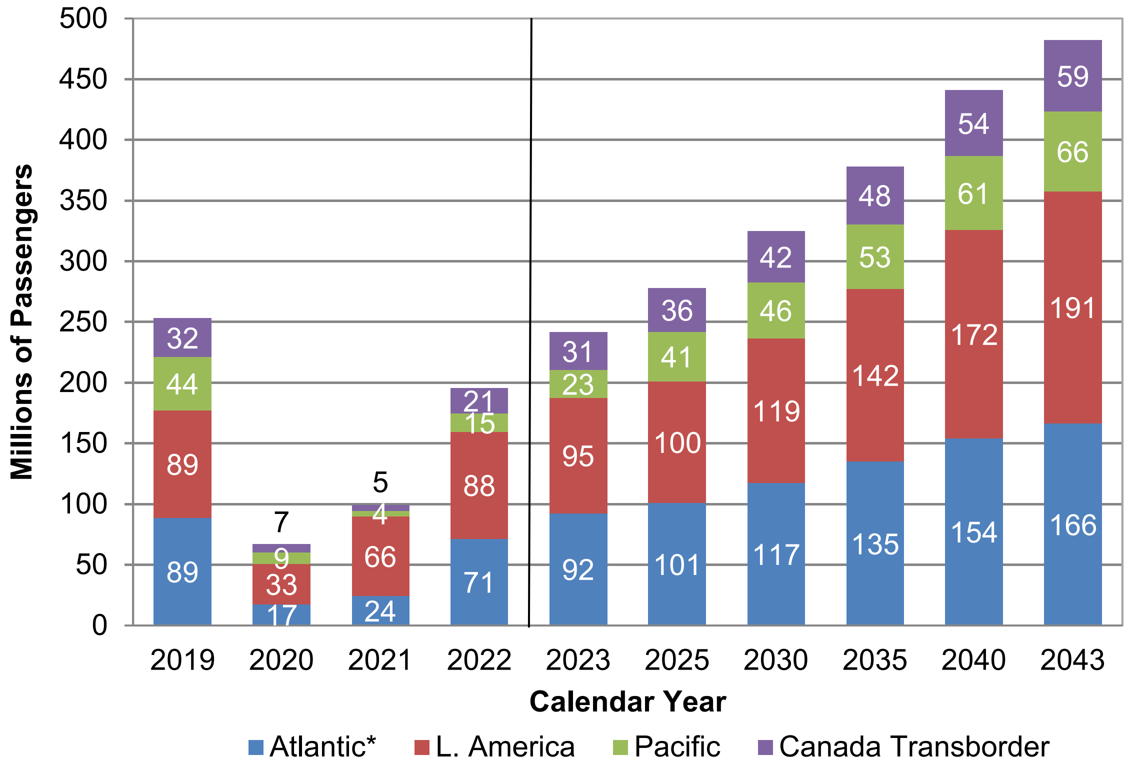
The impact of COVID-19 on travel by region has varied considerably, as will the recovery paths. Factors affecting the responses by market are similar to those affecting travel as a whole: COVID-19 case counts, governmental restrictions, predominant traveler segments, and macroeconomic conditions. As a result, by 2022, enplanements to Latin America had fully recovered followed but the Atlantic region still lagged and the Pacific region had the furthest to go.

For U.S. carriers, Latin America remains the largest international destination with more than twice the enplanements of Atlantic, the next largest in a typical year, due to its proximity to the U.S., strong trade ties, and popular visitor destinations. In 2022, Latin enplanements rose by 55 percent while RPMs rose 64 percent, pushing both measures above their 2019 levels. Much of the strength was fueled by leisure traffic heading to warm weather destinations and by the relatively low number of COVID-19 cases and travel restrictions. Enplanements and RPM growth are expected to pause in 2023 as other regions become viable to leisure travelers before resuming single-digit growth and returning to a long-term trend rate of around 4 percent. Over the twenty-year period 2023-2043, Latin America enplanements are forecast to increase at an average rate of 3.6 percent a year while RPMs grow 4.0 percent a year.

Switching to the Pacific region, it is the smallest in terms of enplanements despite the economic growth and potential of air travel to the region's emerging markets. After falling in 2020 to 42.1 percent of 2019's level, enplanements fell further in 2021 to just 5.8 percent as many countries enforced stringent travel restrictions, especially China, a very large market in the region. RPM also collapsed by similar amounts. In 2022, enplanements and RPM came off the bottom and recovered to about 20 percent of 2019 levels but was held back as some countries' travel restrictions remained in place. In 2023, those measures of activity are expected to continue expanding to above 50 percent. With comparatively slow trend growth, the region's enplanements take time to fully recover to 2019's level but are within 5 percent by 2026 while RPM are fully recovered in that year. From FY2026 through the end of the forecast, Pacific enplanements and RPM are forecast to grow at average rates of 2.3 percent and 2.5 percent, respectively. Although the region is forecast to have the strongest economic growth of any region over the next 20 years, led by China and India, enplanements and RPMs over the period are restrained in part because U.S. carriers continue to provide a majority of their service in the region to Japan as opposed to faster growing countries.

The Atlantic region ranks in the middle between the other two, with pre-pandemic enplanements roughly twice those in the Pacific region and half those in the Latin region. After contracting in 2015 and 2016, Atlantic enplanements began rising to reach 7.0 percent growth in 2019. This growth was supported by U.S. demand as well as growth of Middle East and African markets, even as the European economies slowed in 2019. In 2020, like the other regions, Atlantic enplanements tumbled by 61 percent and then a further 47 percent in 2021 to bottom out at 21 percent of 2019's level. Subsequent percentage gains are large, returning enplanements to 2019 levels in 2023. Although Western Europe is a mature area with moderate economic growth, the economically smaller Middle East and Africa areas are expanding rapidly with GDP growth rates more than twice that of Europe. As a result, a larger share of the forecast aviation demand in the Atlantic region is linked to those two areas, particularly in the second half of the forecast period. Over the forecast horizon from 2023 to 2043, enplanements and RPM in the Atlantic region are forecast to grow at average annual rates of 3.3 percent and 3.6 percent, respectively.

Total Passengers To/From the U.S.
American and Foreign Flag Carriers



Source: US Customs & Border Protection data processed and released by Department of Commerce; data also received from Transport Canada
* Per past practice, the Mid-East region and Africa are included in the Atlantic category.

Total passengers (including Foreign Flag carriers) between the United States and the rest of the world fell even more in 2020, and have recovered less since, than did U.S. carriers alone. Foreign carriers, without the relative strength of domestic markets for support, were forced to reduce capacity more and thereby sacrificed passenger traffic. Total passengers collapsed by an estimated 73.4 percent to 67 million in 2020 as all regions posted losses led by an 80.4 percent reduction in the Atlantic region. In 2021, the Latin American and Atlantic regions saw sizable growth from the previous year, while the Pacific and Canada Transborder regions saw further declines, but by 2022, all regions posted strong, positive growth.

FAA projects total international passenger growth of 24 percent in 2023 as the recovery progresses, with the strongest passenger growth rates in the Transborder and Pacific regions. Total passenger numbers return to above 2019 levels in 2024 – 2023 for all regions except Pacific which returns in 2028. Over the entire forecast horizon from 2023 to 2043, international passengers average growth of 4.4 percent a year, as levels increase from 195 million in 2022 to 482 million in 2043.

The Atlantic and Latin American regions were of comparable size in 2019 but by the end of the forecast period the Latin American region counts about 15 percent more passengers and their growth paths differ. Atlantic growth is faster early on and slows relative to Latin American in later years, consistent with GDP forecasts. Over the 20-year forecast period (2023-2043), the Atlantic region grows at an average annual rate of 4.1 percent while Latin America grows at a rate of 3.8 percent. Although European markets in the Atlantic region are mature and relatively slow growing, other markets such as the Middle East and Africa boost overall growth in the region.

In the Pacific region, passenger levels in 2022 were just a third of those in 2019 and combined with stringent COVID-19 travel restrictions and sluggish Japanese GDP growth that offsets some of the strong economic growth and rising incomes in China, India and South Korea, the outcome is a relatively slow return to 2019 passenger levels in 2028. From 2023 to 2043, passengers between the United States and the Pacific region are forecast to grow 7.2 percent a year.

Like the Atlantic region, Canada transborder is another mature market but is considerably smaller. It is projected to grow at an average rate of 5.1 percent over the forecast period, somewhat faster than the Atlantic region.

System

System (the sum of domestic plus international) capacity contracted 36 percent to 789 billion ASMs in 2020 while RPMs plummeted 47 percent to 548 billion. During the same period, system-wide enplanements fell 44 percent to 509 million. After a tentative beginning towards recovery in 2021, activity surged in 2022 as ASM, RPM and enplanements expanded by 34 percent, 60 percent and 49 percent, respectively. In prior years, U.S. carriers had prioritized the domestic over the international market in terms of allocating capacity as the U.S. saw stronger economic growth than many regions around the world. And by 2022, travel restrictions associated with COVID-19 caused this split to largely continue as domestic capacity was curtailed less than international: down 5 percent in 2022 from 2019 for domestic compared to down 21 percent for international. However, as U.S. carriers continue the process of recovery, international capacity growth rates will outpace domestic, mainly because the international reductions in 2020 were much more severe. Subsequent years through 2043 see carriers revert to slightly faster capacity expansion in domestic markets compared to international driven in part by slightly stronger economic activity.

U.S. mainline carrier enplanement growth in the combined domestic and international market was 56 percent in 2022 while regional carriers carried 20 percent more passengers – a difference explained by the shift in leisure demand as well as the more restrictive capacity constraints faced by regional carriers.

In the domestic market in 2019, mainline enplanements marked their ninth consecutive year of increases, a trend that was abruptly halted in 2020 with a decline of 44 percent but followed two years later by a 52 percent increase in 2022. Similarly, international mainline passengers had posted a tenth consecutive year of growth in 2019, a trend that was also broken in 2020 with a 53 percent decline but then in 2022 was followed by a larger 87 percent increase. Domestic mainline enplanement growth is forecast to slow in 2023, rising 6 percent as enplanements approach 2019 levels. In 2024, domestic enplanements exceed 2019 levels for the first time since the start of the pandemic. With the recovery complete, domestic enplanements resume growth driven by economic fundamentals and average 2.7 percent over the remainder of the forecast. International mainline enplanements follow a similar path with strong growth in 2023, surpassing 2019 in 2024, and trend-like growth through the end of the forecast averaging 3.3 percent.

Although carriers cut capacity aggressively in 2020, the drop in traffic was even greater and system load factor fell from 84.5 percent in 2019 to 69.5 in 2020 and further to 68.5 in 2021 – a combined drop that far exceeded those following both 9/11 and the Great Recession. Load factor recovered sharply in 2022, rising to 81.8 percent. Thereafter, load factor edges gradually higher, plateauing at 85.3 percent in the second half of the forecast.

Cargo

Air cargo traffic includes both domestic and international freight/express and mail. The demand for air cargo is a derived demand resulting from economic activity. Cargo moves in the bellies of passenger aircraft and in dedicated all-cargo aircraft on both scheduled and nonscheduled service. Cargo carriers face price competition from alternative shipping modes such as trucks, container ships, and rail cars, as well as from other air carriers.

U.S. air carriers flew 51.5 billion revenue ton miles (RTMs) in 2022, a mere 0.5 percent increase compared to the previous year's 16.9 percent surge. Domestic cargo RTMs edged down 0.3 percent to 19.8 billion in 2022 while international RTMs expanded 1.0 percent to 31.7 billion. In comparison, for the decade ending in 2019, domestic RTM increased at an average rate of 3.2 percent and international grew at a 3.8 percent rate. The levelling off in RTM resulted from a normalization of consumer purchasing patterns as demand shifted from goods back into services. Air cargo RTMs flown by all-cargo carriers averaged 78.7 percent of the total in the years leading up to 2020 but then spiked to 88.0 percent in 2020 and 2021, with passenger carriers flying the remainder. In 2022, that ratio dropped to 86.3 percent as passenger flights resumed, increasing available belly-hold capacity. Total RTMs flown by the all-cargo carriers declined 1.5 percent in 2022 while total RTMs flown by passenger carriers rose by 0.5 percent. As passenger flights return, the share of cargo on all-cargo carriers will ease, dropping to about 82 percent in 2025.

U.S. carrier international air cargo traffic spans four regions consisting of Atlantic, Latin, Pacific, and 'Other International.'

Historically, air cargo activity tracks with GDP. Other factors that affect air cargo growth are fuel price volatility, movement of real yields, globalization and trade. The forecasts of revenue ton miles rely on several assumptions specific to the cargo industry. First, security restrictions on air cargo transportation will remain in place. Second, most of the shift from air to ground transportation has occurred. Finally, long-term cargo activity depends heavily on economic growth.

The forecasts of RTMs derive from models that link cargo activity to GDP. Forecasts of domestic cargo RTMs use real U.S. GDP as the primary driver of activity. Projections of international cargo RTMs depend on growth in world and regional GDP, adjusted for inflation. FAA forecasts the distribution of RTMs between passenger and all-cargo carriers based on an analysis of historic trends in shares, changes in industry structure, and market assumptions.

After increasing by just 0.5 percent in 2022, total RTMs are expected to remain flat in 2023 as the normalization of consumer demand for goods versus services continues. Because of steady U.S. and world economic growth in the long term, FAA projects total RTMs to increase at an average annual rate of 2.8 percent over the forecast period (from 2023 to 2043).

Domestic cargo RTMs from 2023 to 2043 are forecast to increase at an average annual rate of 2.0 percent. In 2022, all-cargo carriers carried 92.7 percent of domestic cargo RTMs. The all-cargo share is forecast to decline modestly to about 92 percent in the medium-term as passenger flights return to the system. In the long-term, the all-cargo share rises only slightly to 93.4 percent by 2043 based on increases in capacity for all-cargo carriers.

International cargo RTMs also flattened out in 2022 as surface transportation snarls were resolved. As with domestic markets, RTM carried by all-cargo carriers declined slightly in 2022 while that transported by passenger carriers expanded again at a double-digit rate. With the post-pandemic return of passenger flights, RTM on passenger aircraft is expected to continue growing rapidly, increasing about 14 percent per year in both 2023 and 2024. Over the same years, all-cargo RTM will shrink by about 2 percent per year as some tonnage is lost to passenger carriers. The share of international cargo RTMs flown by all-cargo carriers was 82.3 percent in 2022 and is forecast to decline steadily during the recovery period before gradually increasing in line with historical trends and ending at 80.8 percent in 2043.

Following the period of recovery, growth for both types of carriers returns to long-run trend rates. For the forecast period (2023-2043), international cargo RTMs are expected to increase an average of 3.3 percent a year based on projected growth in world GDP with the Other International region having the fastest RTM growth (3.7 percent), followed by Pacific (3.6 percent), Atlantic (2.4 percent), and Latin America region (1.8 percent).

General Aviation

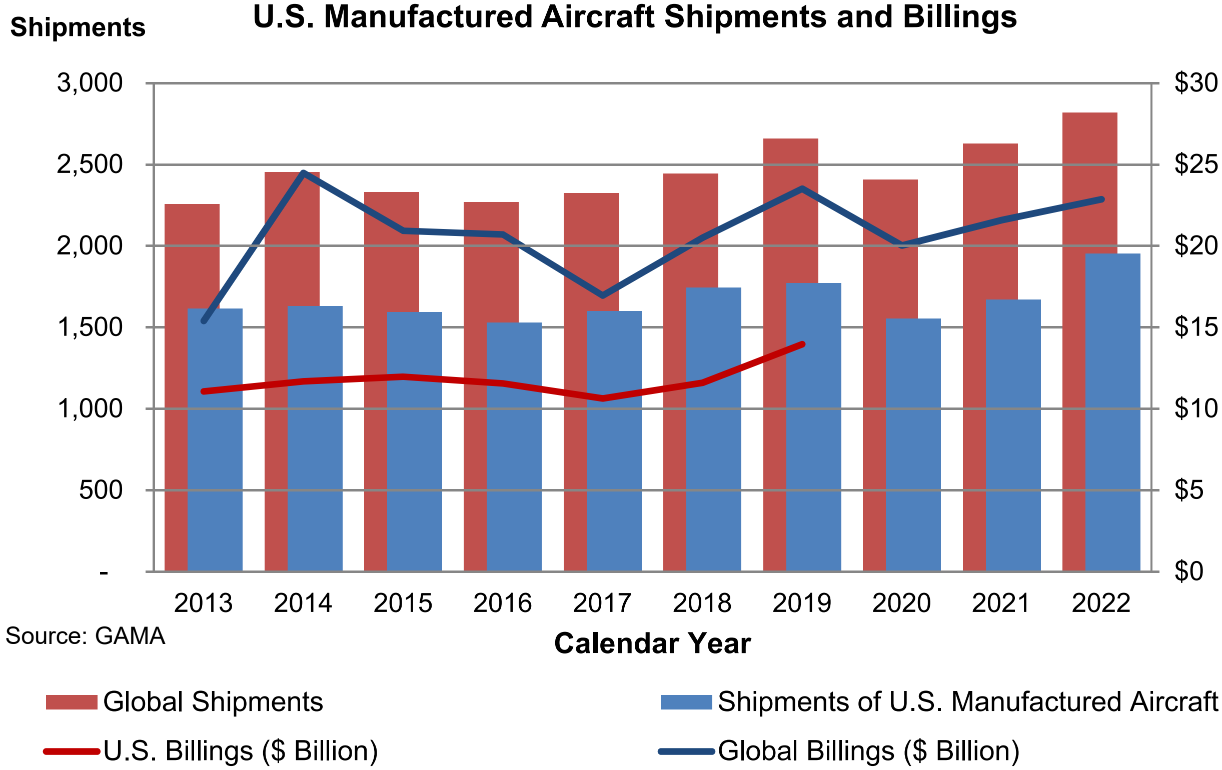
The FAA uses estimates of fleet size, hours flown, and utilization rates from the General Aviation and Part 135 Activity Survey (GA Survey) as baseline figures to forecast the GA fleet and activity. Since the survey is conducted on a calendar year (CY) base and the records are collected by CY, the GA forecast is done by CY. Forecasts of new aircraft deliveries, which use the data from General Aviation Manufacturers Association (GAMA), together with assumptions of retirement rates, generate growth rates of the fleet by aircraft categories, which are applied to the GA Survey fleet estimates. The forecasts are carried out for "active aircraft,"[2] not total aircraft. The FAA's general aviation forecasts also rely on discussions with the industry experts conducted at industry meetings, including Transportation Research Board (TRB) meetings of Business Aviation and Civil Helicopter Subcommittees conducted twice a year in January and June.

The results of the 2021 GA Survey, the latest available, were consistent with the results of surveys conducted since 2004 improvements to the survey methodology. The active GA fleet was estimated to be 209,195 aircraft in 2021 (2.5 percent increase from 2020). Small declines in turbojet and multi-engine piston fleet were more than offset by increases in all the other categories, including a 2.2 percent increase in the largest segment of single-engine pistons, a 2.9 percent increase in rotorcraft, and 6.0 percent increase in experimental aircraft fleets. Total hours flown were estimated to be 26.4 million in 2021, up 17.6 percent from the previous year, 3.4 percent above where they were in 2019 and at their highest level since the historical peak of 2007. Increases were across the board, with the highest absolute and percent increase in turbojet (46.0 percent (much smaller category of gliders and lighter than air aircraft together recorded a 82.0 percent increase in activity).

In 2022, deliveries of the general aviation aircraft manufactured in the U.S. increased to 1,954, 17.0 percent higher than in CY 2021 and 10.3 percent higher than their 2019 level. Deliveries of single-engine piston aircraft were up 15.0 percent, while the much smaller segment of multi-engine piston deliveries were up by 40.0 percent (summing to a 15.4 percent increase in the fixed engine piston deliveries). Business jet deliveries increased by 20.5 percent and turboprop deliveries were up 17.0 percent, amounting for an 18.8 percent increase in fixed wing turbine shipments. While the GAMA statistics for factory net billings were not available yet for the U.S. manufactured GA aircraft, global billings increased in 2022 by 5.9 percent to $22.9 billion.

[2] An active aircraft is one that flies at least one hour during the year.

General Aviation
U.S. Manufactured Aircraft Shipments and Billings



Source: GAMA

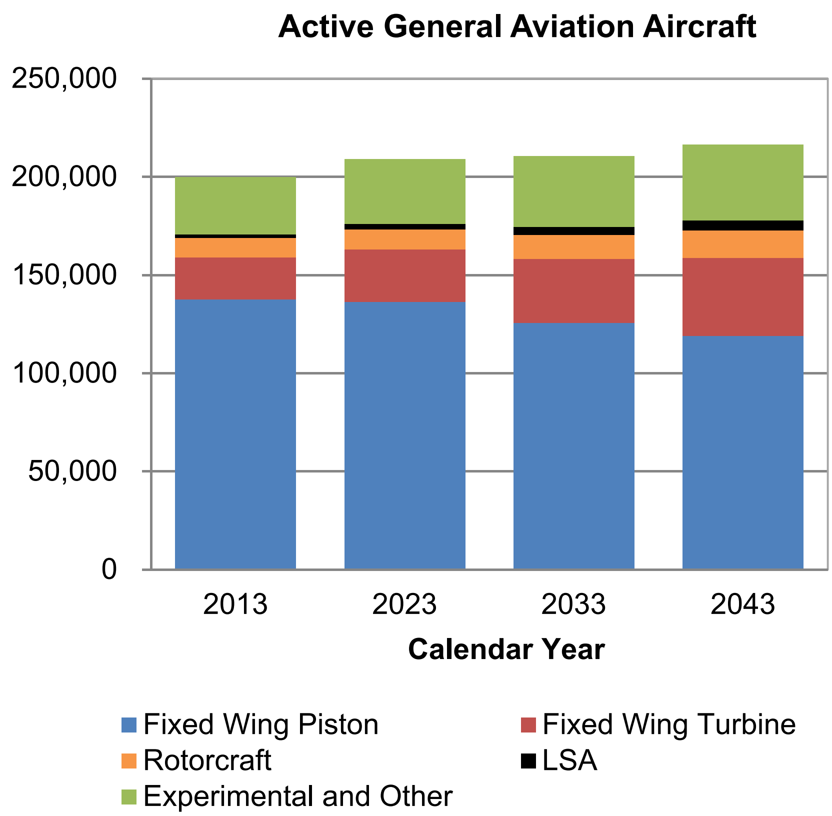
GAMA also reported the rotorcraft deliveries increased at a global level in 2022 in both piston and turbine segments by 7.2 percent and 5.7 percent, respectively.

These current conditions indicate the GA sector, which was not as severely affected by the pandemic as the airlines, completely recovered by activity, surpassing 2019 levels. The active fleet was only 0.8 percent below 2019 levels, with the fixed-wing turbine and experimental aircraft categories above their 2019 levels. The long-term outlook for general aviation, driven by turbine aircraft activity, remains stable. The active general aviation fleet, which showed an increase of 2.5 percent between 2020 and 2021, is forecast to increase from its 2021 level of 209,195 aircraft to 216,395 by 2043, as the declines in the fixed-wing piston fleet are offset by increases in turbine, rotorcraft, experimental, and light sport fleets. The total active general aviation fleet grows by a small increase of 0.2 percent annually.

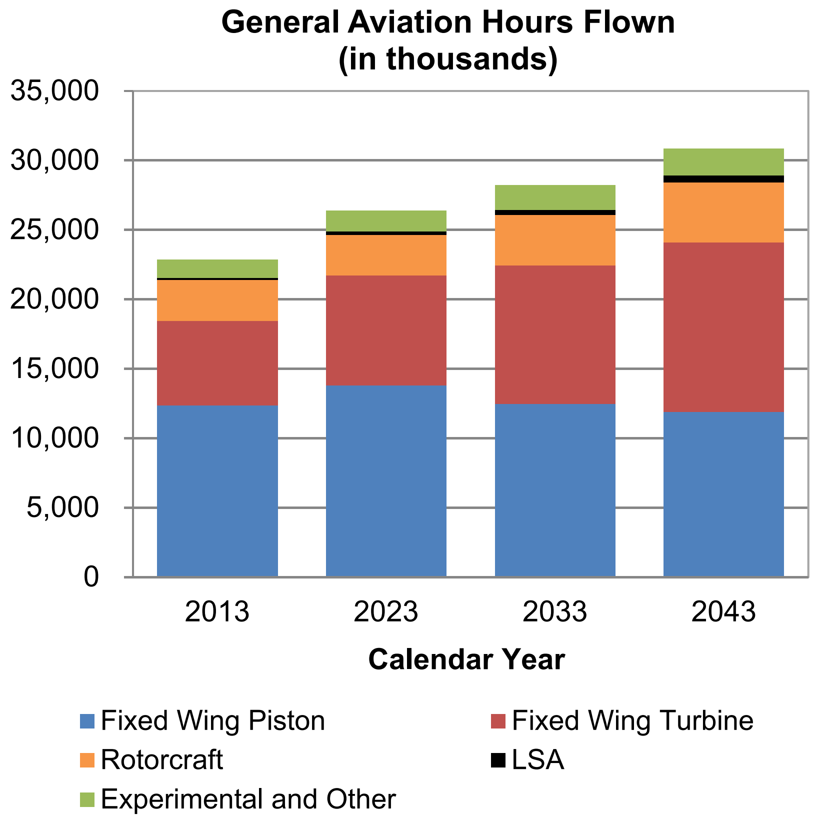
The more expensive and sophisticated turbine-powered fleet (including rotorcraft) is projected to grow by 17,550 aircraft between 2021 and 2043 to total 50,235 in 2043, an average rate of 2.0 percent a year during this period, with the turbojet fleet increasing 2.7 percent a year. When measured from the 2019 levels, the growth rate for the turbine-powered fleet is 1.9 percent. The growth in U.S. GDP and corporate profits are catalysts for the growth in the turbine fleet.

The largest segment of the fleet, fixed wing piston aircraft, is predicted to shrink over the by 19,645 aircraft between 2021 and 2043, an average annual rate of -0.7 percent. Unfavorable pilot demographics, overall increasing cost of aircraft ownership, availability of much lower cost alternatives for recreational usage, coupled with new aircraft deliveries not keeping pace with retirements of the aging fleet are the drivers of the decline.

On the other hand, the smallest category, light-sport-aircraft (created in 2005), is forecast to grow by 3.2 percent annually, adding about 2,595 new aircraft by 2043, nearly doubling its 2021 fleet size of 2,650.



Although the total active general aviation fleet is projected to marginally increase, the number of general aviation hours flown is forecast to increase an average of 0.7 percent per year through 2043, from 26.4 million in 2021 to 30.8 million, as the newer aircraft fly more hours each year. Fixed wing piston hours are forecast to decrease at a slightly faster rate than the fleet, an average of 0.8 percent a year. Countering this trend, hours flown by turbine aircraft (including rotorcraft) are forecast to increase 2.2 percent yearly between 2021 and 2043. Jet aircraft account for most of the increase, with hours flown increasing at an average annual rate of 2.7 percent between 2021 and 2043. The large increases in jet hours result mainly from the increasing size of the business jet fleet.



Rotorcraft activity, positively impacted by increases in oil prices, associated oil exploration and increasing additional demand through slow recovery in the commercial airlines sector improved in 2021. Potential effects of Advanced Air Mobility (including eVTOLs) in the later years of the forecast period are too uncertain yet to include in the forecast. The active fleet of rotorcraft is projected to grow at a similar rate to the previous year's forecast, 1.5 percent a year, driven by higher growth in the turbine segment, going from a total of (piston and turbine together) 10,032 in 2021 to 13,870 in 2043. Rotorcraft hours are projected to grow by 2.1 percent annually between 2021 and 2043.

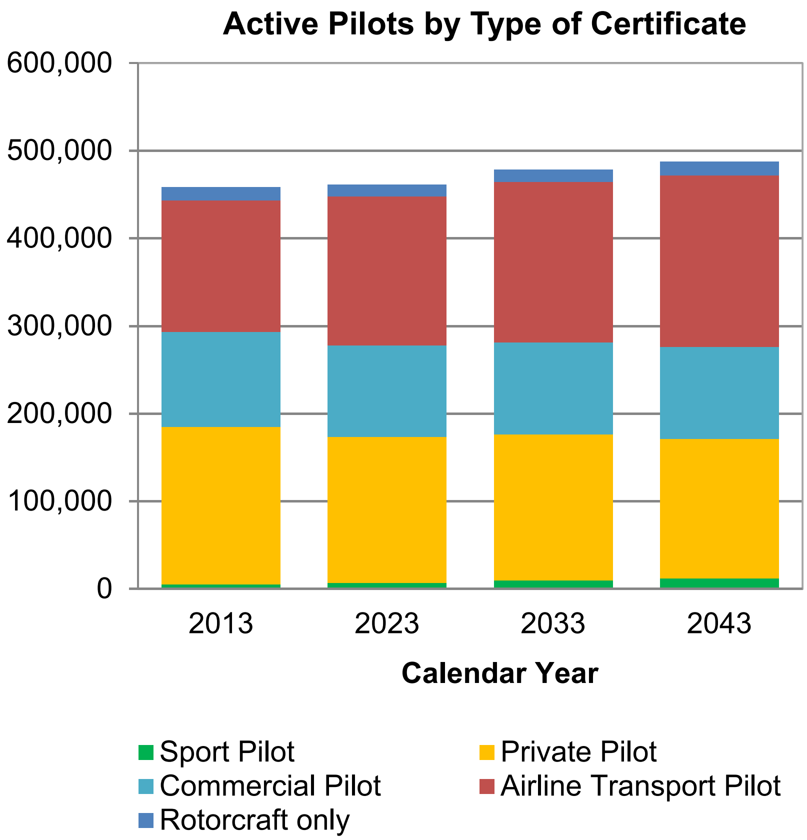
Lastly, the light sport aircraft category is forecasted to see an increase of 3.2 percent a year in hours flown, primarily driven by growth in the fleet.

The FAA also conducts a forecast of pilots by certification categories, using the data compiled by the Administration's Mike Monroney Aeronautical Center. There were 756,928 active pilots certificated by FAA at the end of 2022. The number of certificates in most pilot categories continued to increase, while there small declines in the rotorcraft only and recreational certificates. The FAA suspended the student pilot forecast since 2018. The number of student pilot certificates has been affected by a regulatory change that went into effect in April 2016 and removed the expiration date on the new student pilot certificates. The number of student pilots jumped from 128,501 at the end of 2016 to 149,121 by the end of 2017, and to 280,582 at the end of 2022. The 2016 rule change generates a cumulative increase in the certificate numbers and breaks the link between student pilot and advanced certificate levels of private pilot or higher. There is no sufficient data to perform a reliable forecast for the student pilots.

Commercial and air transport pilot (ATP) certificates have been impacted by a legislative change as well. The Airline Safety and Federal Aviation Administration Extension Act of 2010 mandated that all part 121 (scheduled airline) flight crew members would hold an ATP certificate by August 2013. Airline pilots holding a commercial pilot certificate and mostly serving at Second in Command positions at the regional airlines could no longer operate with only a commercial pilot certificate after that date, and the FAA data initially showed a faster decline in commercial pilot numbers, accompanied by a higher rate of increase in ATP certificates. The number of commercial pilot certificates started to increase since 2017 until showing a slight decline of 0.1 percent in 2022 to 104,498. While the ATP certificate holders increased every year since 2011, significantly reduced number of flights and a large number of parked aircraft due to the pandemic generated an overcapacity for the ATPs employed by the airlines, despite government support to the aviation sector. Consequently, the number of pilots holding an ATP certificate declined in 2020 and 2021, but reached to 166,738 in 2022, a 1.7 percent increase from the previous year (1.1 percent higher than their 2019 level).

Private pilots had stabilized their decline since 2016 at around 162,000 and showed an increase in 2022 to 164,090 from 161,459 in the previous year. Sport pilot certificates, created in 2005, kept their steady increase since their inception to reach 6,957 by December 31, 2022. Rotorcraft pilots continued their decline since 2016 to end up with 13,180 by the end of 2022.

The number of active general aviation pilots (excluding students and ATPs) is projected to increase slightly between 2022 and 2043 from 309,608 to 314,570. The ATP category is forecast to increase by 29,360 (up 0.8 percent annually). The much smaller category of sport pilots are predicted to increase by 2.5 percent annually over the forecast period. Commercial pilot certificates are projected to remain flat between 2022 and 2043. On the other hand, private pilot certificates are projected to decrease at an average annual rate of 0.1 percent over the forecast horizon.


Active Pilots by Type of Certificate
600,000
500,000
400,000
300,000
200,000
100,000
0
2013
2023
2033
2043
Calendar Year
Sport Pilot
Private Pilot
Commercial Pilot
Airline Transport Pilot
Rotorcraft only

FAA Operations

The traffic at FAA facilities underwent drastic changes during the period of 2019 and 2020 from the COVID-19 impact. There was 16.7 percent decline in traffic from 53.3 million in 2019 to 44.4 million in 2020. Activity continued a healthy recovery of 10.2 percent from 47.7 million in 2021 to 52.6 million in 2022. While domestic markets led the way for the recovery from 2020 to 2021, international markets began to pick up steam in 2022. By September 2022, domestic passenger volume has reached 99% of the pre-COVID-19 level while international passenger volume reached 86% of the pre-COVID-19 level.

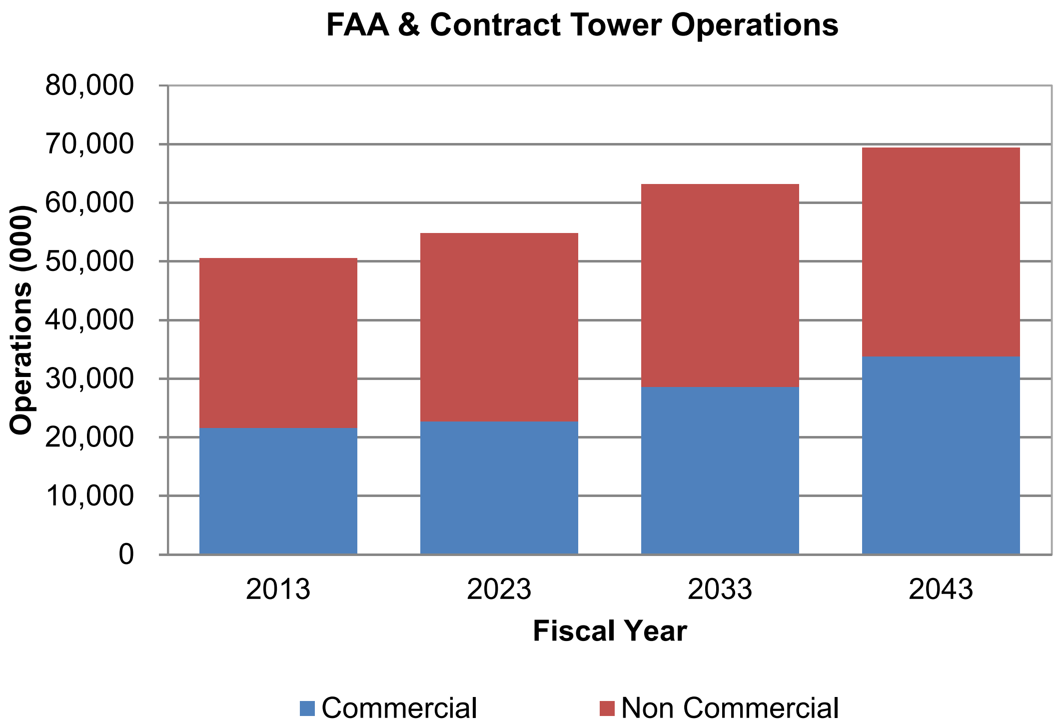
After operations return to pre-pandemic levels, longer-term economic health along with the growth in air travel demand and the business aviation fleet will drive the long-term growth in operations at FAA facilities over the rest of the forecast period. Activity at FAA towers and contract towers is projected to return to pre-COVID levels in 2023 and then increase at an average rate of 1.2 percent a year through 2043 from 54.8 million in 2023 to 69.4 million in 2043. The 1.2 percent annual growth forecast is lower than the 1.5 percent forecast for 2022-2042 last year partially due to the faster aircraft up-gauging. Commercial operations[3] at these facilities are forecast to increase 2.0 percent a year, approximately four times faster than non-commercial operations. The growth in commercial operations is less than the growth in U.S. airline passengers (2.0 percent versus 2.6 percent) over the forecast period due primarily to larger aircraft (seats per aircraft mile) and higher load factors. Both of these trends allow U.S. airlines to accommodate more passengers without increasing the number of flights.

General aviation operations are forecast to increase an average of 0.5 percent a year as increases in turbine powered activity more than offset declines in piston activity. General aviation operations accounted for 55 percent of total operations in 2022. This is slightly higher than pre-COVID share of 51 percent in 2019. The decline of general aviation traffic was relatively mild during the early years of the pandemic where recovery speed was swift, and commercial aviation is now recapturing market share given that its share has increased from 38% to 41% between 2021 and 2022.

The growth in operations at towered airports is not uniform. Most of the activity at large and medium hubs[4] is commercial in nature, as these are the airports where the vast majority (about 89 percent in 2022) of the passenger enplanements in the U.S. occur.

[3] Commercial operations include air carrier and commuter/air taxi operations.

[4] A large hub is defined to have 1 percent or more of total U.S. revenue passenger enplanements in FY 2022. A medium hub is defined to have at least 0.25 percent but less than 1 percent of total U.S. revenue passenger enplanements. In the 2022 TAF there were 30 large hub airports and 34 medium hub airports.



Given the growth in airline demand and most of that demand is at large and medium hubs, activity at the large and medium hubs is forecast to grow substantially faster than smaller airports including small FAA towers[5] and FAA contract towers[6]. The forecasted annual growth in operations is 2.2 percent at large hubs, 1.8 percent at medium hubs, 0.8 percent at small FAA towers, and 0.6 percent at FAA contract towers between 2023 and 2043.

Among the 30 large hubs, the airports with the fastest long-term annual growth forecast are those located along the coastal sections of the country where most large cities are located. Large cities have historically shown to generate robust economic activity, which in turn drives up the airline demand. On the other hand, many of the large hub airports located in the middle of the country are forecast to have slower long-term annual growth. In terms of COVID-19 recovery, the airports with mostly domestic traffic and the ones located at popular leisure destinations are forecast to have shorter recovery timeline.

FAA Tracon (Terminal Radar Approach Control) Operations[7] are forecast to grow slightly faster than at towered facilities. This is in part a reflection of the different mix of activity

[5] Small FAA towers are defined as towered airports that are neither large or medium hubs nor FAA contract towers.

[6] FAA contract towers are air traffic control towers providing air traffic control services under contract with FAA, staffed by contracted air traffic control specialists.

[7] Tracon operations consist of itinerant Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) arrivals and departures at all airports in the domain of the Tracon as well as IFR and VFR overflights.

at Tracons. Tracon operations are forecast to increase an average of 1.4 percent a year between 2023 and 2043. Commercial operations accounted for approximately 55 percent of Tracon operations in 2022 and are projected to grow 2.0 percent a year over the forecast period. General aviation activity at these facilities is projected to grow only 0.4 percent a year over the forecast.

The number of IFR aircraft handled is the measure of FAA En-Route Center activity. Growth in airline traffic and domestic leisure aviation is expected to lead to increases in activity at En-Route centers until the business aviation sector recovers. Over the forecast period, aircraft handled at En-Route centers are forecast to increase at an average rate of 2.0 percent a year from 2023 to 2043, with commercial activity growing at the rate of 2.3 percent annually. Activity at En-Route centers is forecast to grow faster than activity at towered airports and FAA Tracons because more of the activity at En-Route centers is from the faster growing commercial sector and high-end (mainly turbine) general aviation flying.[8] In 2022, the share of commercial IFR aircraft handled at FAA En-Route centers is about 80% percent, which is greater than the 55 percent share at Tracons or the 41 percent share at FAA and Contract Towers.

[8] Much of the general aviation activity at towered airports, which is growing more slowly, is local in nature, and does not impact the centers.

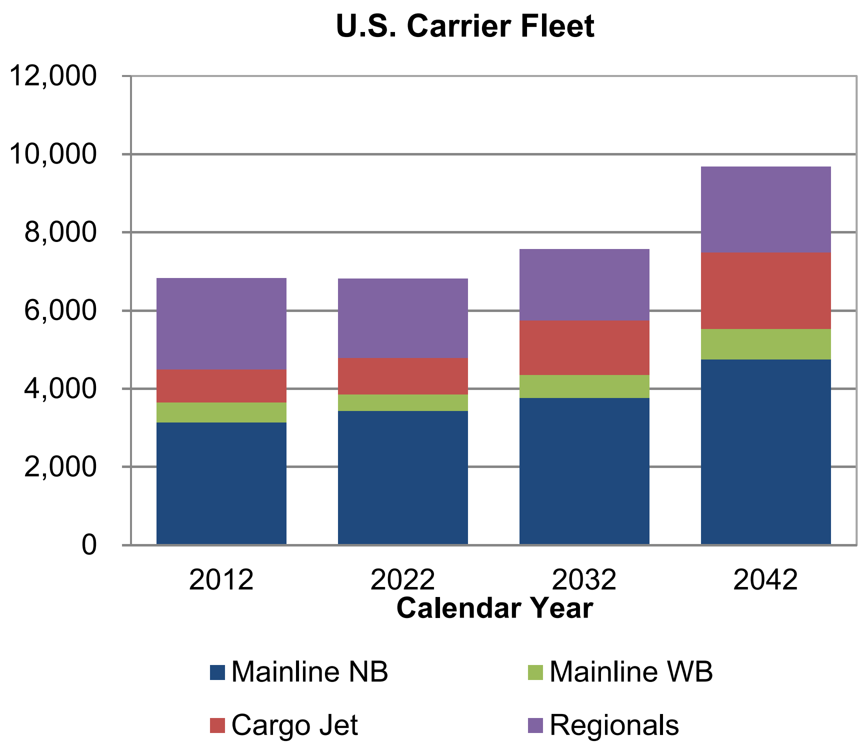
U.S. Commercial Aircraft Fleet

Boosted by the sharp recovery in demand for air travel and cargo, the number of aircraft in the U.S. commercial fleet grew by 18 percent in 2021-22 (an increase of 1,055 aircraft), with many coming off ‘parked’ status. The total number of commercial aircraft is forecast to increase from 6,852 in 2022 to 10,286 in 2043, an average annual growth rate of 2.0 percent a year. The continued recovery in demand from the COVID-19 downturn along with long-term post-COVID increases in demand for air travel and growth in air cargo is expected to fuel increases in both the passenger and cargo fleets.

Between 2022 and 2043 the number of jets in the U.S. mainline carrier fleet is forecast to grow from 3,915 to 5,925, a net average of 96 aircraft a year as carriers continue to remove older, less fuel efficient narrow body aircraft. As the industry recovers from the COVID-19 downturn, many aircraft that were temporarily parked are returning to the fleet, resulting in a large increase in the fleet (approximately 193 aircraft per year) in the first two years of the forecast and then slower rates thereafter. The narrow-body fleet (including E-series aircraft as well as A220-series at JetBlue and A220-series at Delta) is projected to grow 80 aircraft a year as carriers replace current technology 737 and A320 family aircraft with the next generation MAX and Neo families. The wide-body fleet grows by an average of 19 aircraft a year as carriers add 777-8/9, 787’s, A350’s to the fleet while retiring 767-300/400 and 777-200 aircraft. In total the U.S. passenger carrier wide-body fleet increases by 3.2 percent a year over the forecast period.

The regional carrier fleet is forecast to increase from 2,002 aircraft in 2022 to 2,387 in 2043 as the fleet expands by 0.8 percent a year (18 aircraft) between 2022 and 2043. Carriers remove 50 seat regional jets and retire older small turboprop and piston aircraft, while adding 70-90 seat jets, especially the E-2 family in the second half of this decade. By 2043, the number of jets in the regional carrier fleet totals 2,158, up from 1,626 in 2022. The turboprop/piston fleet is forecast to shrink by 39% from 376 in 2022 to 229 by 2043. These aircraft account for 9.6 percent of the regional fleet in 2043, down from 18.8 percent in 2022.

The cargo carrier large jet aircraft fleet is forecast to increase from 935 aircraft in 2022 to 1,974 aircraft in 2043 driven by the growth in freight RTMs. The narrow-body cargo jet fleet is projected to increase by 20 aircraft a year as 737-800/900MAX’s are converted from passenger use to cargo service. The wide body cargo fleet is forecast to increase 30 aircraft a year as new 777-8/10 and converted 767-300 aircraft are added to the fleet, replacing older MD-11, A300/310, and 767-200 freighters.


U.S. Carrier Fleet
12,000
10,000
8,000
6,000
4,000
2,000
0
2012
2022
2032
2042
Calendar Year
Mainline NB
Mainline WB
Cargo Jet
Regionals

Commercial Space

The FAA's Office of Commercial Space Transportation (AST) licenses and regulates U.S. commercial space launch activities including launch and reentry of vehicles and operation of non-federal launch and reentry sites authorized by Executive Order 12465 and Title 51 U.S. Code, Subtitle V, Chapter 509 (formerly the Commercial Space Launch Act). Title 51 and the Executive Order also direct the U.S. Department of Transportation to encourage, facilitate, and promote U.S. commercial launches. The FAA's mission is to license and regulate commercial launch and reentry operations and non-federal launch sites to protect public health and safety, the safety of property, and the national security and foreign policy interests of the United States.

The FAA licenses launches or reentries carried out inside the U.S. and by U.S. persons (which includes U.S. corporations) inside or outside the United States. The FAA does not license launches or reentries the U.S. Government carries out for the Government (such as those owned and operated by National Aeronautics and Space Administration (NASA) or the Department of Defense). Amateur-class rockets do not require a FAA license or permit[9].

To accomplish its mission, the FAA performs the following major functions:

- Maintains an effective regulatory framework for commercial space transportation activities,
- Provides guidance to prospective commercial operators on how to comply with regulatory requirements for obtaining an authorization and operating safely,
- Evaluates applications for licenses, experimental permits, and safety approvals for launch and reentry operations and related commercial space transportation activities,
- Evaluates applications for licenses for launch and reentry site operations,
- Monitors and enforces regulatory compliance through safety inspections of launches, reentries, sites, and other regulated commercial space activities,
- Provides U.S. Government oversight of investigations associated with the mishap of an FAA authorized launch or reentry,
- Facilitates the integration of commercial space launch and reentry operations into other modes of transportation including the National Airspace System (NAS) by establishing appropriate hazard areas and limits to ensure the protection of the public,
- Coordinates research into the safety, environmental, and operational implications of new technologies and the evolving commercial space transportation industry,

[9] Per 14 CFR Chapter 1, Part 1, section 1.1: Amateur rocket means an unmanned rocket that is propelled by a motor or motors having a combined total impulse of 889,600 Newton-seconds (200,000 pound-seconds) or less; and cannot reach an altitude greater than 150 kilometers above the earth's surface.

- Conducts outreach to the commercial space industry by hosting working groups and conferences,
- Collaborates with Government partners, such as the Department of Defense and NASA to assure consistent approaches to regulations, policy, and standards, and
- Conducts outreach to international counterparts to promote the U.S. regulatory framework across the world.

In addition to AST headquarters offices in Washington, D.C., AST maintains staff with assigned duty locations near active launch ranges to facilitate communication with space launch operators and to implement FAA's regulatory responsibilities more efficiently. AST personnel are currently assigned to duty locations in close proximity to: Kennedy Space Center and Cape Canaveral Space Force Station in Florida; Johnson Space Center in Texas; and, Vandenberg Air Force Base and the Mojave Air and Space Port in California. FAA also directly supports NASA's commercial space initiatives by providing on-site staff at both the Johnson Space Center and Kennedy Space Center to coordinate the FAA's regulatory and compliance activities with NASA's development and operational requirements for commercial space.

Regulatory Safety Oversight Activities of FAA

The business cycle from the time a firm first contacts FAA until the last launch of a licensed operation can be several years. There are many activities performed by FAA during this cycle. The most notable activities are described here.

Pre-Application Consultation for Licenses, Experimental Permits, and Safety Element Approvals

Prospective applicants seeking commercial space transportation licenses, experimental permits, or safety approvals are required by regulation to consult with FAA before submitting their applications. During this period, FAA assists them in identifying potential obstacles to authorization issuance and determining potential approaches to regulatory compliance. In addition, many new operators are seeking to incorporate new technologies, vehicle types, or operational models creating opportunities for FAA to assist in determining the applicable regulations or approach to regulatory compliance.

Licenses, Permits, and Safety Element Approvals

FAA authorizes commercial space transportation activities via the issuance of licenses, permits, and safety element approval. Though many licenses authorize multiple launches (for mature launch systems), the need remains for FAA to also issue individual launch licenses for systems that are still maturing towards a high level of reliability. Furthermore, with the dynamic commercial space industry, FAA often evaluates launch and reentry systems and operations that are evolving and changing, which may ultimately require license modifications or issuance of new licenses.

Inherent in the review process is the requirement to conduct policy reviews and payload reviews. When conducting a policy review, FAA determines whether the proposed launch, reentry, or site operation presents any issues that would jeopardize public health and safety or the safety of property, adversely affect U.S. national security or foreign policy interests, or be inconsistent with international obligations of the United States. If not otherwise exempt from review, FAA reviews a payload proposed for launch or reentry to determine whether the payload would jeopardize public health and safety, the safety of property, U.S. national security or foreign policy interests, or the international obligations of the United States. The policy and/or payload determination becomes part of the licensing record on which FAA's licensing determination is based.

FAA reviews and issues launch and reentry site operator licenses and license renewals. FAA also reviews and evaluates launch site license applications for launch sites located in foreign countries but operating with U.S.-licensed launch or reentry systems. FAA coordinates planning among Federal, state, and local governments and with the commercial range operators or users. As part of the evaluation of applications for launch licenses, reentry licenses, and site operator licenses, FAA also conducts environmental reviews consistent with its responsibilities under the National Environmental Policy Act.

FAA anticipates issuing a growing number of safety element approvals for space launch systems equipment, processes, technicians, training and other supporting activities. FAA reviews, evaluates, and issues safety approvals to support the continued introduction of new safety systems, safety operations applications, and safety approval renewal applications.

Safety Analyses

FAA conducts flight safety, system safety, maximum probable loss, and explosive safety analyses to support the evaluation and issuance of licenses and permits. FAA also evaluates and analyzes the performance of safety-critical space flight personnel to determine how they affect public safety risk. In the near future, as commercial firms become more involved with human space flight activity, AST and the FAA's Office of Aerospace Medicine may evaluate, analyze, and determine the health risks to the space flight participants (crew and space flight participants) due to natural and flight-induced launch and reentry environments, as well as any hazardous ground operations directly associated with the flight.

Inspections and Enforcement

FAA currently conducts as many as 330 preflight/ reentry, flight/ reentry, and post-flight/ reentry safety inspections per year. Inspections often occur simultaneously at any of the 12 licensed U.S. and international commercial space launch sites, as well as at 4 Federal launch ranges and 3 exclusive-use launch sites. The establishment of non-federal launch sites requires additional inspections in areas such as ground safety that have traditionally been overseen by the U.S. Air Force (now the U.S. Space Force) at Federal ranges. At spaceports and launch sites with high launch rates (e.g., Cape Canaveral Space Force Station, Vandenberg Air Force Base, the Mid-Atlantic Regional Spaceport, and Spaceport America), at least 80 percent of inspections are typically conducted by locally-based field inspectors. Additionally, as a result of the COVID-19 pandemic, many inspections in fiscal year (FY) 2020 were handled remotely. FAA will leverage this approach in the upcoming years in order to respond to a dynamic operational tempo, minimize cost, and increase efficiency.

Mishap Investigations

Mishap events have demonstrated that FAA needs to have the capacity to oversee the investigation of at least two space launch or reentry mishaps or accidents simultaneously anywhere in the world, and to lead/oversee as many as nine investigations during a single year. FAA anticipates an increase in mishaps with new operators coming online. FAA reviews all applicant mishap plans and accident investigation procedures as part of the license and permit evaluation process.

NAS Integration

AST works in partnership with all FAA lines-of-business, notably the Air Traffic Organization (ATO) and Office of Airports (ARP) to support the safe and efficient integration of commercial launch and reentry operations through the NAS and its system of airports and air traffic managed by the ATO. AST expects an increased level of interaction with the ATO, ARP, and the FAA Office of NextGen (ANG). Further, AST works with the ATO as FAA develops technologies to facilitate safe and efficient integration of commercial launch and reentry operations through the NAS, including technologies to improve the integration of launch and reentry data into FAA air traffic control systems and technologies to improve the timely and accurate development and distribution of notices of aircraft hazard areas.

FAA's Launch and Reentry Operations Forecast

FAA's 5-year launch and reentry operations forecast relies on data collected from operators and prospective applicants as the starting point for its launch and reentry forecasts, tying launch and reentry forecasts directly to anticipated operations by commercial space transportation firms known to FAA. As commercial space activity is still a highly dynamic and rapidly evolving industry, FAA's forecasting methodology continues to take a conservative view of industry growth by using historical launch activity data to establish better forecasting parameters for both new applicants and existing operators.

There are several factors that magnify the challenges associated with predicting the number of launches and reentries to expect in a given year. They include:

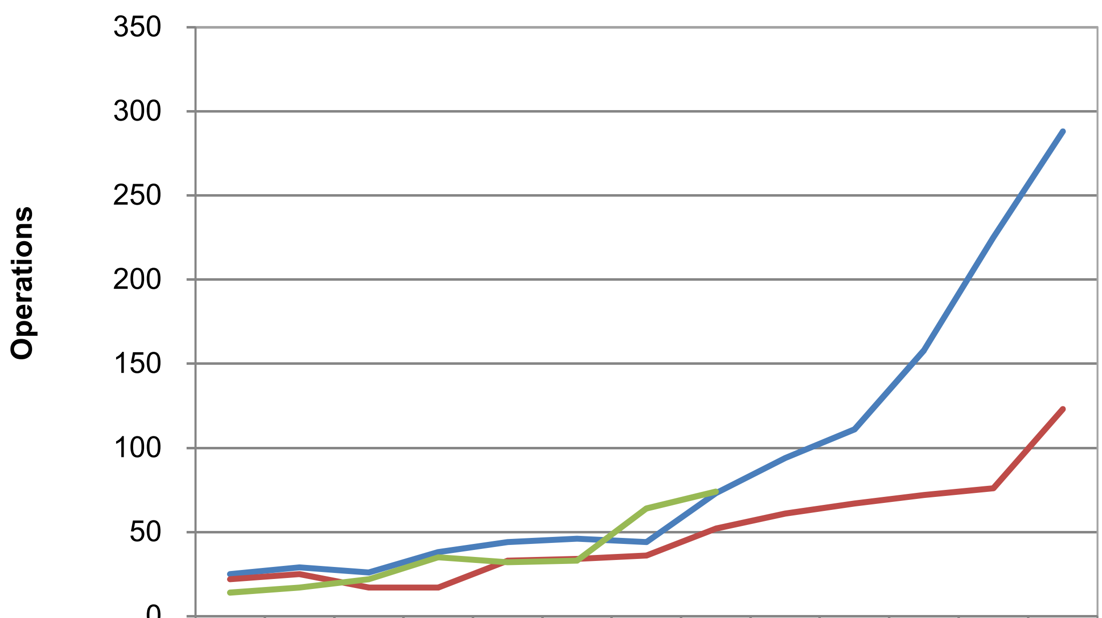
- list of firms intending to launch or actually launch is dynamic,
- continued development of new technologies,
- launch rates for reusable launch vehicles,
- commercial human spaceflight by both government astronauts and private citizens,
- dynamic nature of flight test programs, and
- mishaps.

New technologies [e.g., reusable launch vehicles (RLVs)] allow a faster operational tempo, and at the same time, early use of these technologies can increase the probability of a mishap. A mishap can drastically impact launch plans for one or more firms. Investigations and subsequent "return to flight" for firms impacted by a mishap can take months. FY2023 forecast data was collected in summer 2022 and finalized in September 2022.

However, there are reasons for optimism around the future of space activity moving forward. Space data, products, and services provide tangible benefits and economic opportunity to the American people as well as people all over the world. Firms are motivated towards new technology that is expected to increase launch cadences year over year. Interest and demand for space tourism as well as demands for placement of satellites and other equipment is anticipated to grow with each successful space mission. Likewise, as launch/reentry activities increase investment opportunities are also expected to grow with the global space economy approaching $1 trillion through the next decade. FAA has licensed approximately 563 launch/reentries since 1989, with 42% or 238 launch/reentries occurring in just the past five years (FY2018-2022). FY2022 actuals were the highest in U.S. history at 74, accounting for 13% of the activity since 1989.

FAA is forecasting launch and re-entry activity to increase from a low-high range of 61-94 in FY2023 to a low-high range of 123-288 by FY2027. Much of this increase is attributable to the lineup of reusable vehicles, the growing demand for commercial satellite services, and the expectation for increased human space exploration. Considering these factors, the following table and graph provide FAA's forecasts through 2027, as well as historical activity.

FAA Authorized Operations Forecast, Fiscal Year



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Forecast High	25	29	26	38	44	46	44	73	94	111	158	225	288
Forecast Low	22	25	17	17	33	34	36	52	61	67	72	76	123
Actual	14	17	22	35	32	33	64	74					

It is important to note all FAA-authorized commercial space operations are included in this forecast, regardless of where they occurred in the world. That is, not all launch and reentry activity occurs at one location, for example, at Cape Canaveral, Florida. In the past year, FAA licensed launches and reentries throughout the world, including multiple reentries in the Pacific and Atlantic Oceans and nine licensed launches from New Zealand. This forecast, however, does not include launch activity not authorized by the FAA (e.g. U.S. Department of Defense or non-commercial NASA launches), launch activity for other nations, and this forecast is not tied exclusively to satellite demand.

Additional Factors Affecting Forecast Accuracy

Commercial space transportation is a rapidly evolving industry. The industry's growth through technological innovation and the development of new markets increases the challenges associated with forecasting commercial space transportation operations.

New Commercial Launch Technologies and Operations are Emerging Rapidly

The commercial space transportation industry is exploring a variety of new technologies and new approaches to space launch and reentry. In late 2015, both Blue Origin and Space Exploration Technologies Corp. (SpaceX) successfully demonstrated the reusability of their vertically launched rockets. Both companies are now developing a new generation of much larger orbital vehicles that will launch and land in a vertical configuration. In 2022, 56 of 60 Falcon 9 launches were accomplished using reused boosters. While these new orbital-class vehicles are expected to lead to increases in the number of annual launch and reentry operations over the next four years, if the trend is realized, greater increases may continue in the future, as the upper end of the forecast shows in fiscal years 2024 through 2027. Other U.S. commercial entities are also developing a number of launch vehicles for medium and small payloads. In the medium launch sector ULA's Vulcan, Rocket Lab's Neutron, and Relativity Space's Terran R vehicles are scheduled to begin launching over the next few years. In the small launch vehicle sector Virgin Orbit's LauncherOne, Relativity Space's Terran 1, ABL's RS1, Firefly's Alpha, Astra Rocket 3 have all made their first launch attempts during the past few years. At the same time, state and local governments are joining with commercial firms to promote additional launch and reentry sites, and some firms are seeking to establish launch sites for their exclusive use. This added launch capacity sets the stage for simultaneous operations and an increase in the number operations per year.

New Markets for Commercial Space Transportation Continue to Emerge

The continuing development of commercial space transportation technology has spurred new markets for commercial space transportation services. As the commercialization of space flight demand increases on suborbital and orbital launches, new and reusable vehicles are emerging. With SpaceX and Blue Origin leading the way for reusable rocket development, there are a number of other private companies following suit. The introduction of reusable rockets is a significant cost reducer and thereby encourages more exploration into space.

States and municipalities have sought to open new spaceports to attract commercial space transportation and associated high-tech firms and create technology hubs for research and development. In 2021, Blue Origin flew its first crewed mission into space. Since 2008, NASA has managed the Commercial Resupply Services (CRS) program, which acquires transportation services from commercial providers to deliver cargo to and from the International Space Station (ISS). In 2021 and 2022, SpaceX successfully transported NASA astronauts to the International Space Station. The first crewed launch of Boeing's vehicle for NASA's crewed missions (Starliner) is scheduled for April 2023. The commercial vehicles used by NASA for cargo and crew transportation will have other commercial applications that increase the capabilities of the commercial space transportation industry as a whole.

Looking further afield, there are several companies in the regulatory pipeline seeking authority to land commercial vehicles on the Moon, establish private-sector space stations, service satellites on-orbit, and establish launch sites using non-traditional technologies like railguns and tube launchers. Additional FAA resources may be needed to determine how these unprecedented commercial space ventures will impact public safety and U.S. national interests.

Unmanned Aircraft System and Advance Air Mobility

New Entrants: Analysis and Forecasts

Drones have been experiencing healthy growth in the United States and around the world over the past decade. The last few years have been no exception despite the profound impact of COVID-19 on the overall economy. A drone consists of a remotely-piloted aircraft and its associated elements—including the control station and the associated communication links—that are required for safe and efficient operation in the national airspace system (NAS). The introduction of drones in the NAS has opened up numerous possibilities, especially from a commercial perspective. That introduction has also brought operational challenges including safe and secure integration of drones into the NAS. Despite these challenges, the drone sector holds enormous promise; potential uses range from individuals flying solely for recreational purposes to individual businesses carrying out focused missions to large companies delivering commercial packages and delivering medical supplies. Public service uses, such as conducting search and rescue support missions following natural disasters, are proving promising as well.

This section provides a broad overview covering recreational and commercial (or Part 107) unmanned aircraft[10] and their recent trends, as gathered from trends in registration, surveys, tracking overall market, and operational information. Using these trends and insights from the industry, the FAA produces a number of forecasts. Forecasts reported in the following sections are driven primarily by the assumptions of the continuing evolution of the regulatory environment, the commercial ingenuity of manufacturers and operators, persistent recreational uses, and underlying demand for drone services. The sectoral analyses are enhanced by discussion of recent survey findings, data on imported equipment, remote pilots and waiver and exemptions of small UAS. The section also provides analysis and forecasts of large UAS. Finally, an analysis of new and emerging sector of Advance Air Mobility is provided together with some initial projections drawn

[10] These are also called, interchangeably, hobby or model and non-hobby or non-model UAS, respectively. On October 5, 2018, the President signed the FAA Reauthorization Act of 2018 (Pub. L. 115-254). Section 349 of that Act repealed the Special Rule for Model Aircraft (section 336 of Pub. L. 112-95; Feb. 14, 2012) and replaced it with new conditions to operate recreational sUAS without requirements for FAA certification or operating authority. The Exception for Limited Recreational Operations of Unmanned Aircraft established by section 349 is codified at 49 U.S.C. 44809 [see https://bit.ly/30tUf1Z for more details]. Recreational fliers, under Section 349, are referred to as "recreational fliers or modeler community-based organizations" [see https://bit.ly/2PUhMCI]. In previous notes including other documents of the Agency, these terms are often interchanged.

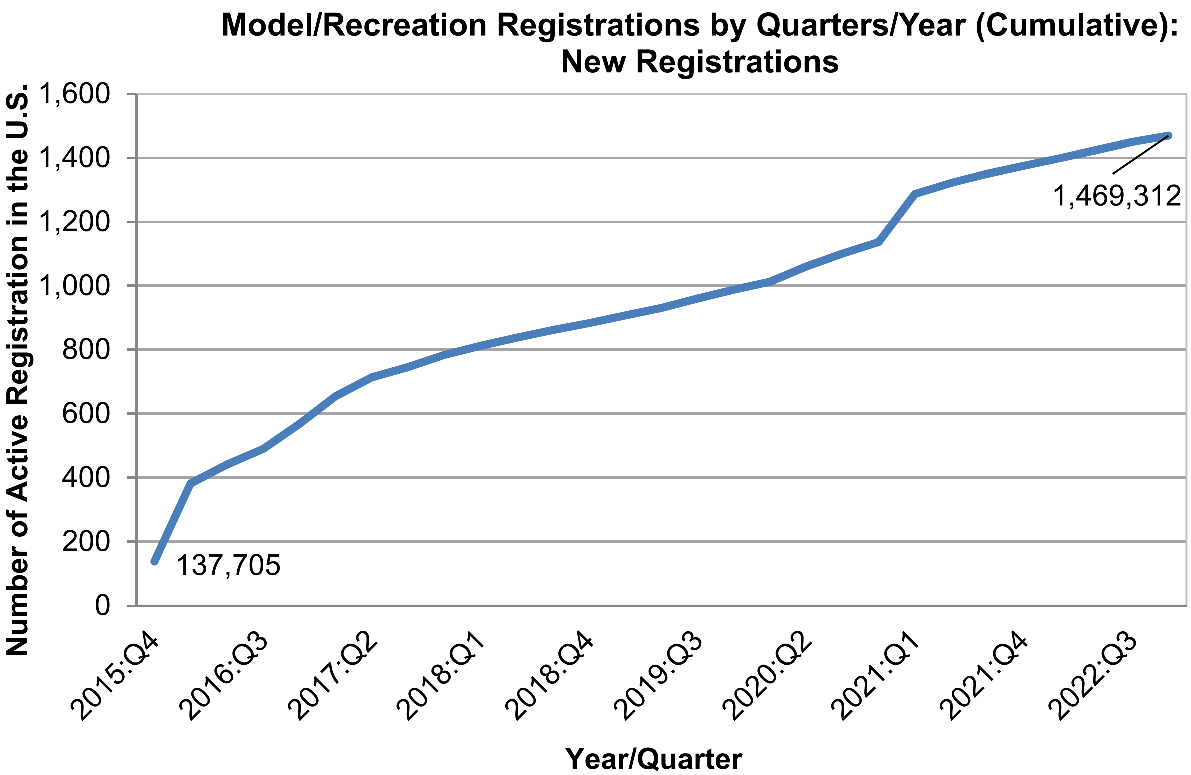
from FAA sponsored and other research, government and industry reports.

Trends in Recreational/Model Aircraft New Registration

The FAA's online registration system for recreational/model small drones went into effect on December 21, 2015. This required all drones weighing more than 0.55 pounds (or 250 grams) and fewer than 55 pounds (or 25 kilograms) to be registered using the on-line system[11] or the existing (paper-driven) aircraft registry. Registration was free for the first 30 days, and $5 thereafter. Following a temporary halt in registration due to an order from the US Appeals Court in Washington, DC in May, 2017 (Taylor v. Huerta), the registration requirement for all model aircraft was reinstated in December, 2017 with the National Defense Authorization Act (NDAA) [Pub. L. 115-91, Sec. 1092]. The NDAA extended the registration for three years for those registered prior to December, 2017. New registration resumed after the temporary halt was removed. On October 5, 2018, the President signed the FAA Reauthorization Act of 2018, which formalized new conditions for recreational use of drones.[12]

With the continuing registration, over 1.47 million (new) recreational drone owners had already registered cumulatively with the FAA by end of December, 2022.[13] On average, new owner registration stood at around 7,866 per month during January – December 2022 with some expected peaks during the holiday seasons and summer. In comparison, the year before (in 2021), average new owner registration stood at around 10,200 per month during January – December.

[11] See https://bit.ly/2IfJ1cm.
[12] See https://bit.ly/3zwYhJM for more details.
[13] For our estimate and projections using the registration database, applying to recreational, commercial/Part 107 and remote pilots, we use only those who are registered in the US and the territories for the period January – December, 2022. Furthermore, we draw a clear distinction between new registrations, cancellations, and renewals in this document which have been explained later on.



The current pace of new registration has decreased compared to last year in the same period; average new monthly owner registration during 2022 stood at 2,334 less than observed the year before in 2021. It is very similar to what we observed the year before in 2020 (-2,500) and this trend has been continuing over the last few years.

Forecasts Using New Registrations vs. Effective/Active Fleet

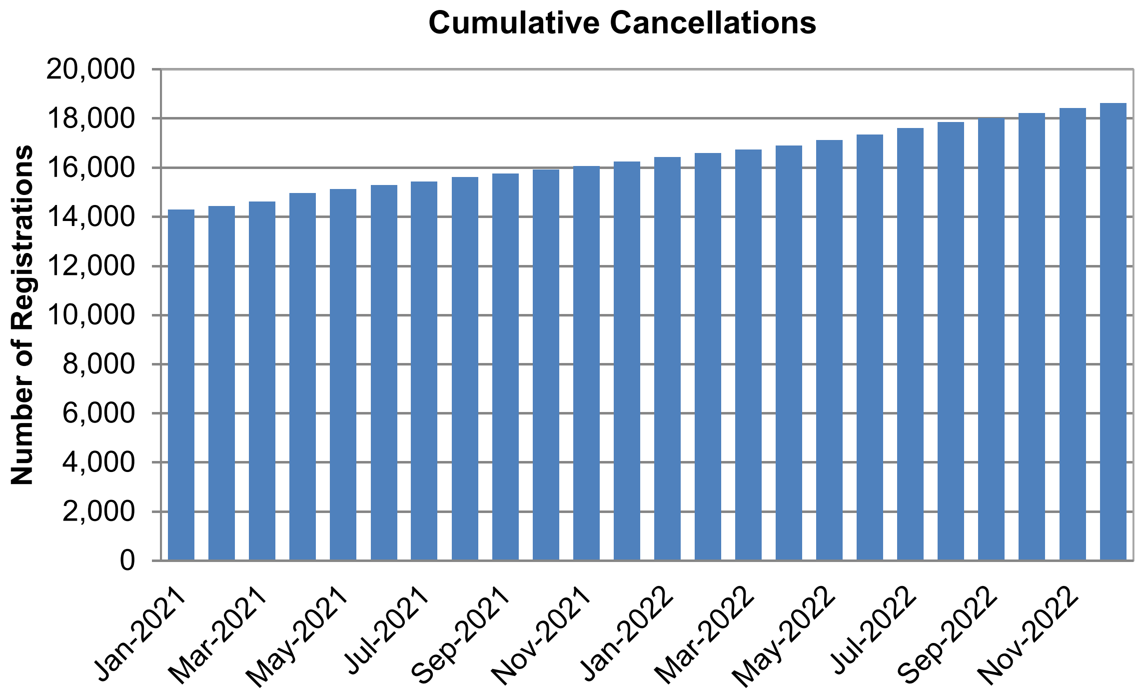
As noted in earlier Aerospace Forecast reports, small drones are registered for 3 years while remote pilot (RP) certifications are valid for 2 years.[14] Following the Taylor vs. Huerta ruling and the FAA's authority over registration via NDAA, the Agency elected to extend the registration period, for all drones registered prior to December 12, 2017, for three years. Thus, December 12, 2020 marked the first effective renewal date. As a result of this sequence of events, as noted in last year's report, approximately 800,000 small drone registrations were due for renewal in December 2020.

The beginning of the registration renewal afforded the FAA an opportunity to analyze the data, including getting rid of duplicate and spurious registrations. Following this process, an examination of the data provided an opportunity for the FAA to discern the effective/active fleet more succinctly using the following five elements: Cancellations, defined as number of registrations canceled by user; Expiry, defined as the number of registrations expired (i.e., effectiveness of expiry); New, defined as the number of brand new registrations (i.e. new registration number) that are reported in the preceding section; Renew, defined as the number of registrations renewed prior to expiration; and Renew+, defined as the number of registrations renewed after expiration.

Cumulative cancellations were, on average, 17,493/month for the time period of January 2022 – December 2022 (or averaging around 198 new cancellations, or the average gaps between the two bars in the graph below, for each month during the January – December 2022 timeframe). For the years 2021-2022, these numbers for cumulative cancellations and average new monthly cancellations stood at 16,400 and 188, respectively:[15]

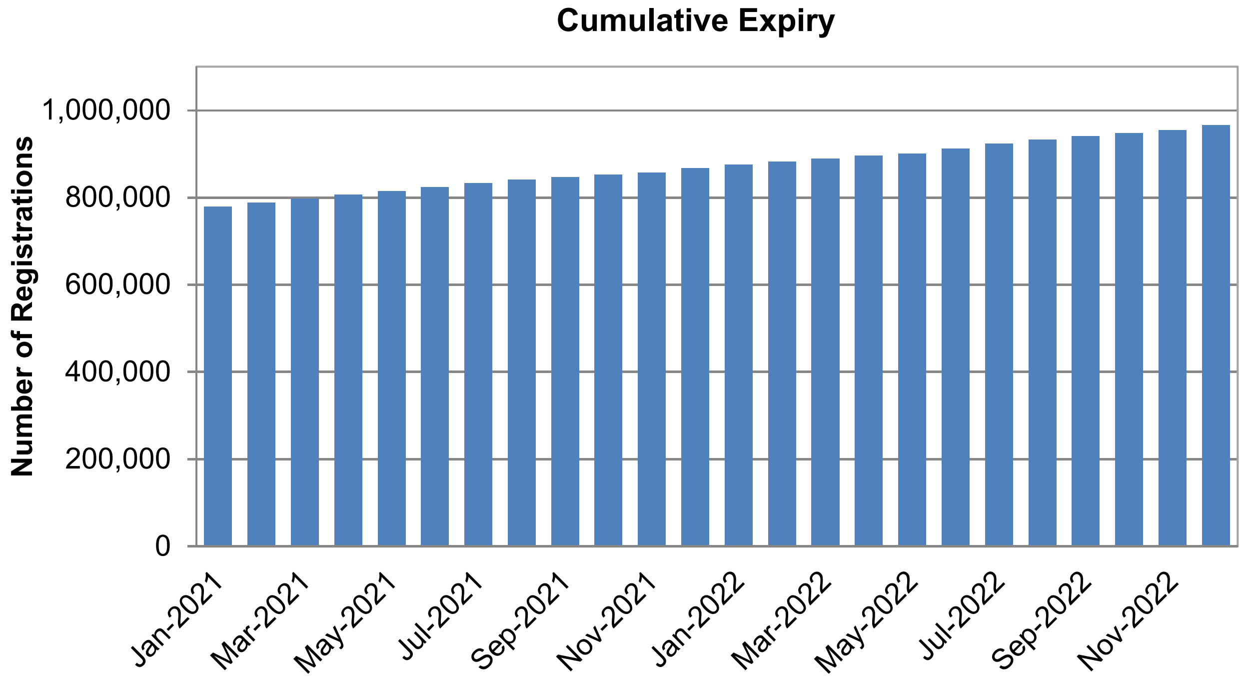
[14] See https://bit.ly/2IfJ1cm; and https://bit.ly/2AUacmT

[15] We report cumulative numbers throughout this document for two reasons: first, cumulative numbers reflect the stability of the trend over time, taking into account past changes; and second, differences between the two numbers (i.e., bars from the graph) capture the changes between two particular time periods.

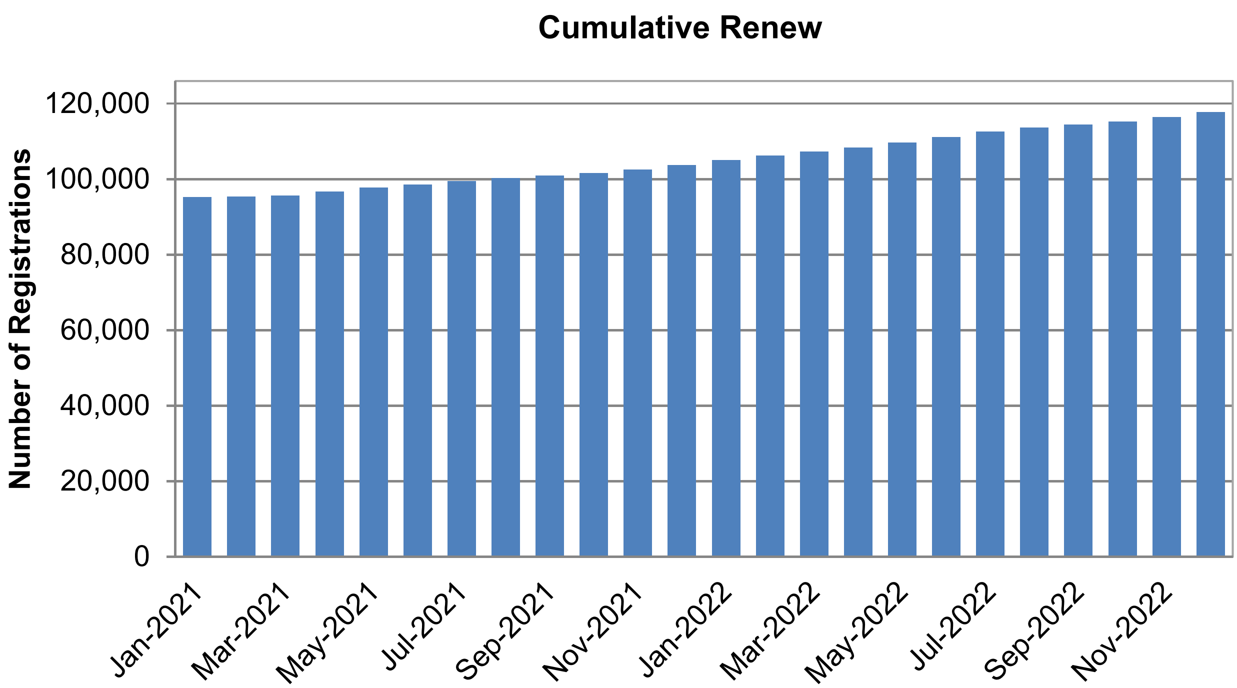


We extend the data by one more year this year and observe that trend in cancellations remain the same as reported last year; cumulative cancellations, on average, stood at around 15,313 with new monthly cancellations at 179 during January-December, 2021. These numbers are comparable to what we observe during 2022.

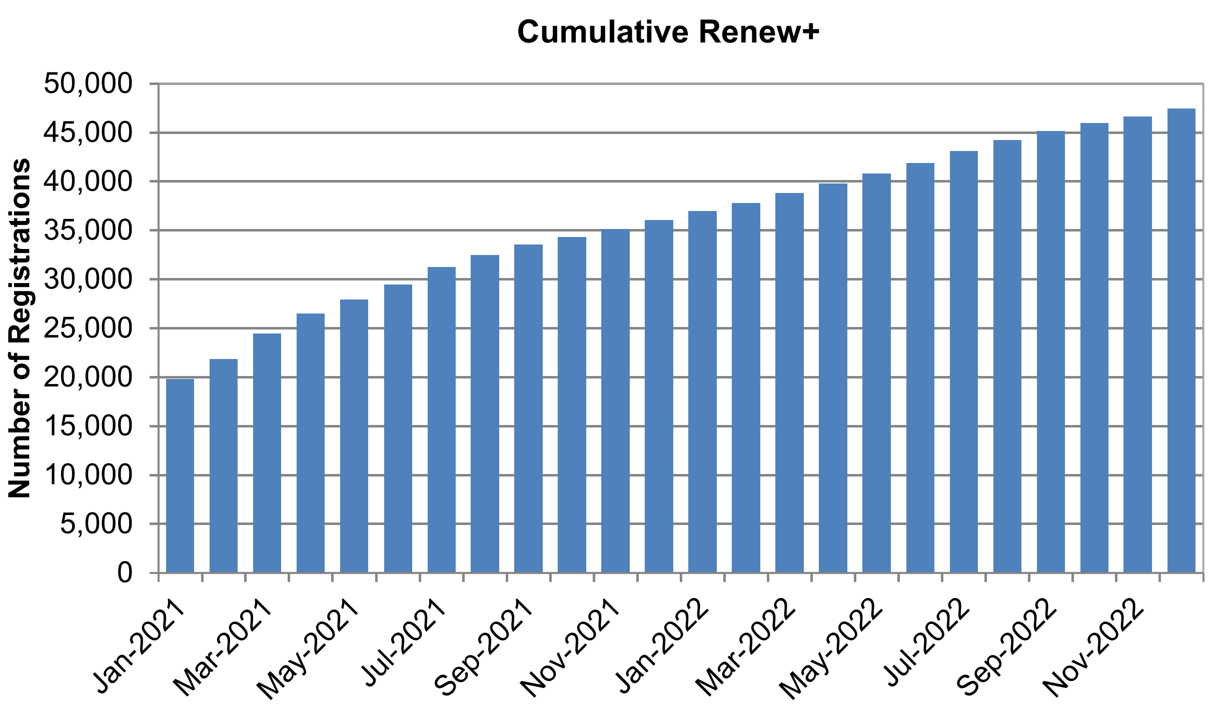
On average, cumulative registrations expired at a rate of more than 825,000/month following the immediate and substantial adjustment in December 2020, as noted above and as shown below. This is equal to a little more than 8,192 new average expiries for each month during January – December 2022; during the years 2021-2022, it was calculated to be 8,336/month:



Renewal or re-registrations prior to expiry date has been picking up speed. From the year before last year's (2021) observed 98,984/month on a cumulative basis, this past year (January-December, 2022), renewals climbed up to 111,445 (or 1,170 new average renewals, in comparison to 712 new average renewals the year before for each month during January – December 2021). For the past two years (2021-2022) as a whole, 105,215/month renewed on a cumulative basis with new average renewals standing at around 941/month. This was almost three times higher than Renew+ on a cumulative basis, as reported below:

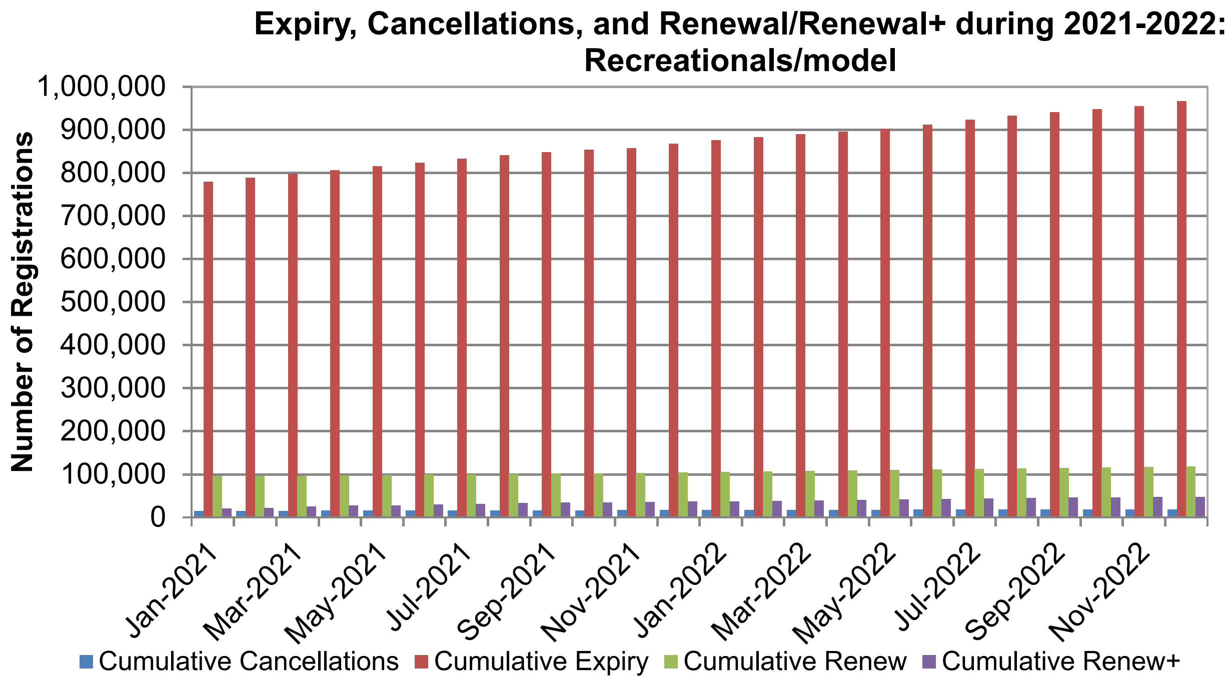


Renew+, re-registrations after expiry date, logged on cumulative average of 42,369/month during January-December, 2022. This is equivalent to approximately 950 new average Renew+ registrations for each month during January – December 2022 and are reported in below:



For the two years (2021-2022) in aggregate, cumulative renewal+ stood at 35,877/month with new renewals+ at 1,365/month.

A summary of the above 4 charts is provided in below to narrate the relative contributions of cancellations, expiry, renew and renew+:



As noted from the above discussion, relative contributions of individual elements remain the same over the past two years with cumulative expiry contributing the most.

We calculate active/effective fleet using the five elements. Calculating active/effective registrations for a particular day requires calculating the "net gain/loss" of registrations for each preceding day; and then adding them together with the given day (i.e. calculating the running sum).

The following are the contributions[16] of each element to the day's net gain/loss calculations:[17]

- Cancel: (-1 for each registration);
- Expire: (-1 for each registration);
- New: (+1 for each registration)
- Renew: (0); and
- Renew+:(+1 for each registration)[18]

An example of this calculation may be constructed as follows: calculating the net gain/loss for recreational registration for August 9, 2022 (an arbitrary date, same as reported last year), where Cancel = 7; Expiry = 344; New = 307; Renew = 44; and Renew+ = 32 were reported for recreational operators/modelers.

Thus, Net Gain/Loss for August 9, 2022 =

7 X (-1) + 344 X (-1) +

[16] We attribute this methodology of calculations to the UAS Integration Office (AUS), provided internally to facilitate last two year's forecasts.

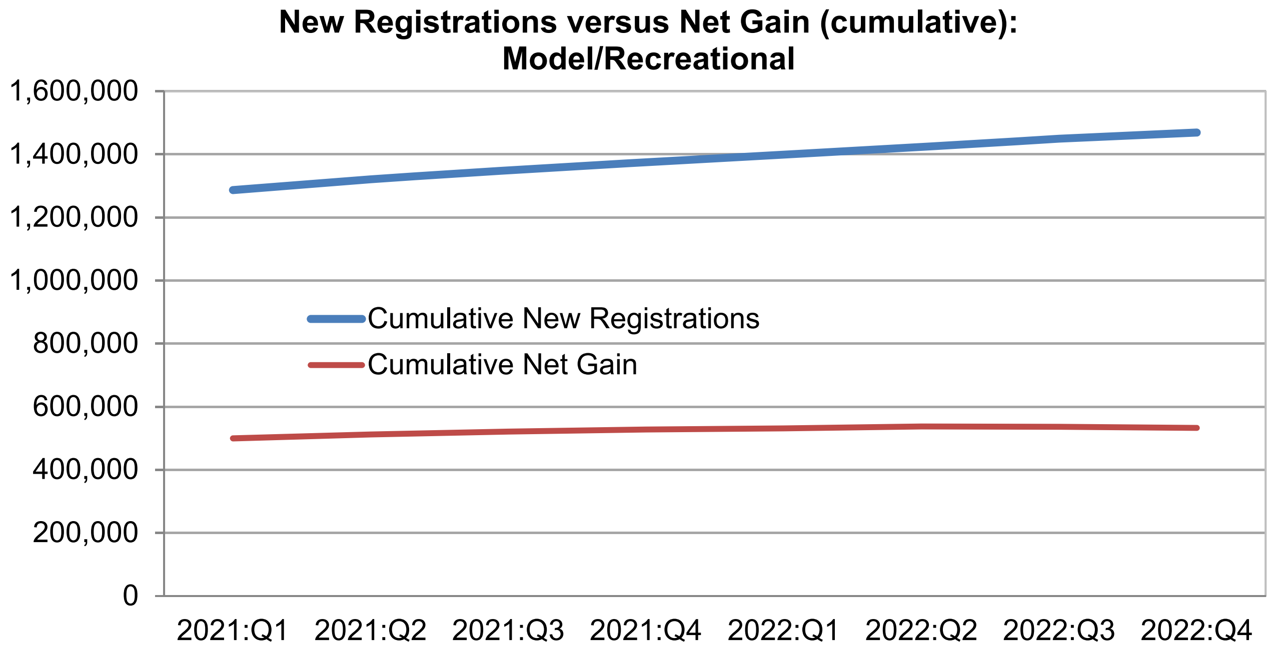
[17] For cumulative new registration trends, see the final graph preceding this section.

[18] It is important to note here that renew+ is a replacement for cancellation on a one-on-one basis.

307 X (1) + 44 X (0) +

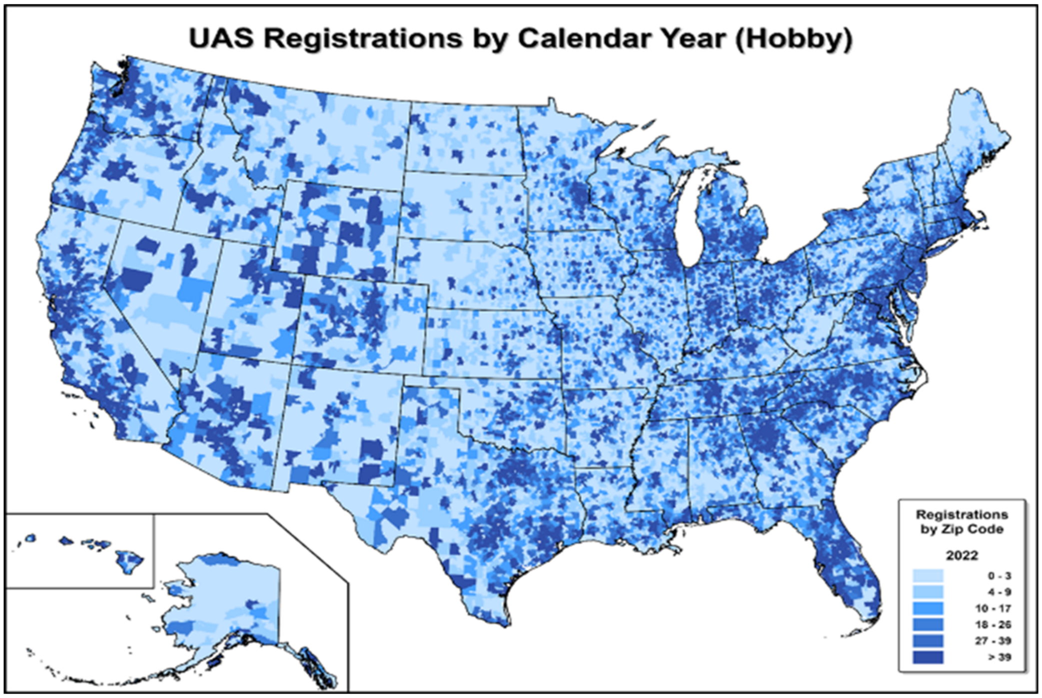
32 X (+1) = -12

Finally, a comparison chart capturing the difference between cumulative new registrations and. effective/active registrations, using cumulative net gain/loss for recreational registrations, is provided below covering the entire period of 2021-2022:[19]



Recreational registration, and thus ownership of small drones, is distributed throughout the country. Using the data available in December 2022, the spatial distribution of recreational ownership by zip codes (shown below) demonstrates that small drones continue to be distributed throughout the US, with denser ownership mapping closely to the population centers or densities of the zip codes, as expected.

[19] There are two important aspects making the difference: (a) the base; and (b) the rate of change in two lines. For cumulative net gain/loss, the base is highly influenced by substantial expiry and cancellations implemented in December 2020, as discussed above; the rates of change (or slope) of the cumulative net gain/loss line is influenced by these two elements plus new registrations and Renew+ re-registrations. In comparison, new registration counted cumulatively has substantial base thus accounting for the difference between the two lines while new monthly registrations is the primary factor driving the rate of change for cumulative new registrations line.



At present, recreational ownership registration does not correspond one-to-one with aircraft. Unlike their commercial non-model counterpart, the registration rules for recreational operators do not require owners of recreational small drones to register each individual aircraft; only operators are registered. For each registration, therefore, one or more aircraft may be owned. In some instances, there is no equipment associated with registration. Free registration at the initial phase may have incentivized some to create a registration without any equipment to report. Notwithstanding these challenges, there is information available, both from industry and academia and surveys, allowing us to understand aircraft ownership. Furthermore, as a result of robust strategic drone research planning, the FAA has launched various research activities to understand the possible magnitude of the sector as well as implications for likely aircraft that may be used for recreational flying, as well as the safety impacts on the small drone fleet from gradual integration into the NAS. Finally, the Agency has incorporated outside analysis and launched surveys to understand the magnitude of the sector including forecasting efforts.

As noted in earlier annual reports, forecasts of small drones were based primarily on new registrations without considering the effective/active fleet for reasons described in the beginning of the section (e.g., lack of renewals required; and expiry/cancellations were not imposed). However, now that data on elements leading to calculate net gain/loss (i.e., via expiry, cancellations, new registration and renewals) are available, more granular forecasts can be made, particularly the lower bound, using the calculation of effective or active fleet. With over 1.47 million new recreational operators cumulatively registered as of December 2022, the FAA estimates that there are approximately 1.69 million sUAS in the fleet distinctly identified as recreational aircraft. Comparing with industry sales and other data noted earlier, we conclude that the number of recreational aircraft is almost 15% higher than ownership registration.[20] Applying cumulative net gain/loss calculations from above, the effective/active fleet is estimated to be around 612,220 as of December 2022. This provides us the lower bound of effective/active fleet of recreational small drones in the NAS.

A comparison of last year's data (2021) with this year's (2022) shows the annual growth rate for new registration to be approximately 6.7%, a drop from the year before (10.2%). Nevertheless, the increasing trend was possible due to the continuation of drones playing a dominant role in recreation, a continuation facilitated by decreasing equipment prices (e.g., average price of $750 or less), improved technology such as built-in cameras and higher capability sensors, and relatively easy maneuvering. Nevertheless, similar to all technologies fueling growth of hobby or recreational items, (e.g., cell phone and video game consoles, and prior to that, video cameras and video players), the trend in recreational small drone ownership registration has been slowing. It is likely to slow down further as the pace of falling prices diminishes and the early adopters begin to experience limits in their experiments, or simply because recreational eagerness plateaus.

Given trends in registration and market developments, the FAA forecasts that the recreational small drone market will saturate at around 1.82 million units over the next five years.[21],[22] However, there is still some upside uncertainty due to further changes in technology, including battery life, faster integration from a regulatory standpoint, and the likely event of continued decreasing prices. This leads to upside possibilities in the forecast of as many as 1.89 million units by 2027. In contrast, there are some low-side uncertainties, chief among them is the lack of renewal (i.e., before and after expiry dates), followed by expiry and cancellations. The inertia, loss of interests, or lack of recreational opportunities may be key factors leading to the observed trends in renewal. Nevertheless, if renewals are kept up over time, effective/active fleet would likely converge to base forecasts, i.e., derived from cumulative new registrations combined with multiplicity of craft ownership. In the presence of slower renewal tendency, as data presently indicates, it is likely that the effective/active fleet will be lower than that derived from base forecasts. This provides the FAA with an opportunity to derive low-side forecasts using effective/active fleet calculations. Nonetheless, low-side uncertainty growth trajectory (i.e., annual growth rates) tracks closer to the base forecast. A forecast base (i.e., likely), together

[20] This calculation involves taking into account retirement, redundancy, and loss of aircraft corresponding to ownership registration. As aircraft become sturdier and operators more situationally aware, this rate has been changing and we expect it to change dynamically over time. Assumptions tying ownership to aircraft holding and issues related to compliance have been discussed [See https://bit.ly/3U73HEC for a recent study by the National Academy of Public Administration on these issues.]

[21] These forecasts have two dimensions worth emphasizing. When looked at from the cumulative base, "total" captures the number of drones that are reported to be in the system (i.e., base and high); while "effective/active fleet" refers to how many aircraft are presently operating in the system (i.e., low).

[22] As we extend the forecast time period by a year from 2026 to 2027 for rolling 5-year projections, the sector is expected to expand by around 16,000 from what we forecasted last year for 1.8075 million in 2026 to 1.8234 million in 2027.

with high and low scenarios, is provided in the table below:[23]

Total Recreation/Model Fleet (Million sUAS Units)

Fiscal Year	Low*	Base**	High**
Historical			
2022	0.6122	1.6885	1.6885
Forecast			
2023	0.6205	1.7502	1.7622
2024	0.6393	1.7854	1.8158
2025	0.6548	1.8035	1.8520
2026	0.6634	1.8149	1.8757
2027	0.6685	1.8234	1.8918

*: Effective/Active fleet counts combined with multiplicity of craft ownership.

**: New registration counts combined with multiplicity of craft ownership.

Last year, the FAA forecasted that the recreational small drone sector would have around 1.6965 million drones in 2022 in base case, a growth rate exceeding 7.2% from the year before (2021). Actual data for 2022 using new registration came in lower by 8,000 units with around 1.6885 million units accounted for by the end of 2022. Thus, our forecast of recreational small drones last year overshot by -0.47% for 2022, (or 1.6885 million actual aircraft vs 1.6965 million aircraft projected last year). In contrast, our last year's forecast of low scenario stood at around 650,900 for 2022. In reality, actual data came to be 612,200 (or around 39,000 lower). Thus, our forecast of lower range last year overshot actual by over 6%.

The FAA uses the trends observed in registrations, particularly over the past year; calculation of net gain/loss (described above) this year; information from the survey conducted in 2018 and ongoing this year; expert opinions distilled from Transportation Research Board annual workshops; review of available industry forecasts; market/industry research; and time-series models fitted on monthly data underlying annual data reported in the above table. These apply to all three elements reported above: low, base, and high forecasts. Using these, the FAA forecasts that the recreational small drone fleet will likely (i.e., base scenario) attain its peak over the next 5 years, from the present 1.69 million units now to approximately 1.82 million units by 2027 thus attaining cumulative annual growth rate of 1.6% during 2022-2027.

[23] As noted earlier, low scenario reports effective/active fleet using a net gain/loss calculation. By definition, low scenario differs from base and high scenarios, which are based on new registrations only. Hence, a low scenario counting of fleet for the year 2022 is markedly different than the baseline and high scenario for the same year.

Following a similar growth trajectory as the base, there will be approximately 668,500 active/effective small drones over the next five years in 2027, which is now the low forecast for recreational/model small drones. This ensures a cumulative annual growth rate of 1.8% during 2022-2027. Active/effective fleet count is derived and projected based on the net gain/loss calculation discussed above. The high scenario, on the other hand, may reach as high as 1.89 million units (or, 2.3% cumulative annual growth rate). High scenario projection is based on the trends in base forecast.

Notice that eventual saturation at somewhat higher levels, in comparison to last year's projections, reflects slightly higher new registration by recreational flyers observed during 2022 and extension of the forecast project by a year. The increased new registration trend, in part driven by COVID-19, may or may not continue in the longer run.[24] In comparison, low side forecasts assume the present trend in renewals combined with new registration followed by similar expiry and cancellations. Nevertheless, the growth rates underlying these numbers are fairly steady in the initial years, but fade faster in the last two to three years. The gradual saturation that is projected in five years and beyond in the recreational small drone fleet parallels other consumer technology products and the Agency's projections from last few years, particularly with respect to base and high forecasts. However, both the numbers and the growth trajectory for the low scenario (i.e., effective/active fleet) are fundamentally different than years earlier than the past couple years for reasons described above. Nevertheless, it provides a lower bound that is likely to be closer to reality in terms of small drones that are in use and operationally effective in the NAS.

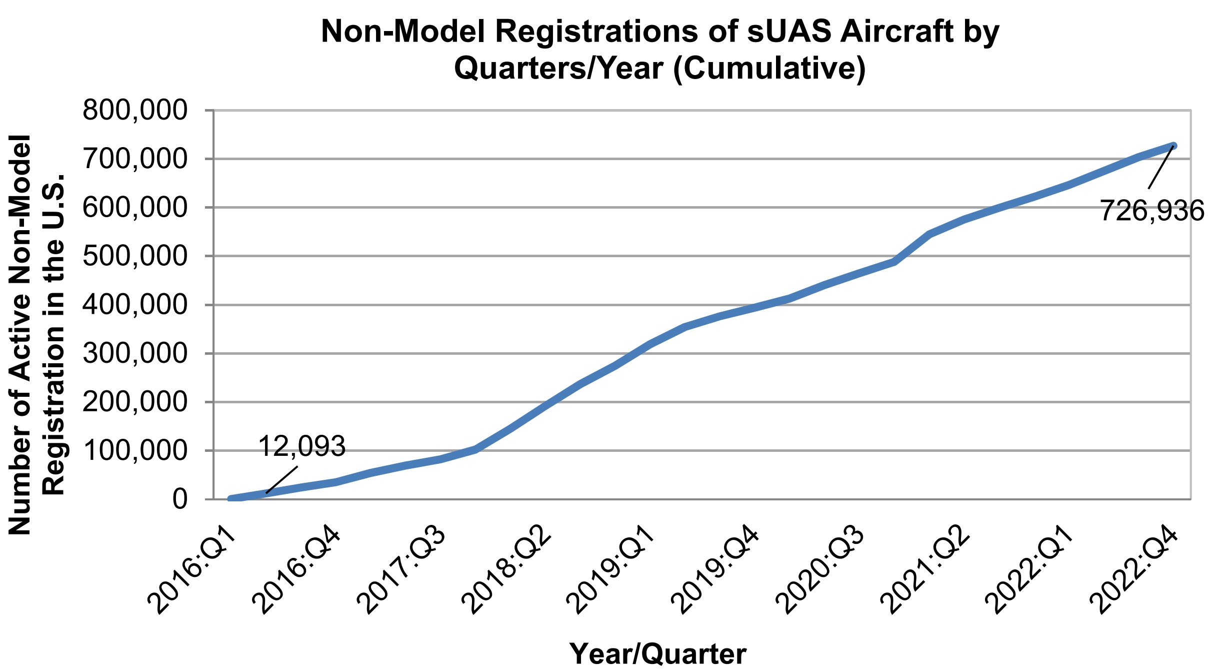
The Recreational UAS Safety Test (TRUST)

Under the most recent (2018) reauthorization bill,[25] new requirements for recreational pilots have been introduced [See P.L. 115-254 – exception for limited recreational operations of unmanned aircraft]. TRUST is the safety test for recreational/model small drones operators. It provides education and testing for recreational flyers on important safety and regulatory information. All recreational flyers must pass an aeronautical knowledge and safety test and provide proof of test passage – the TRUST completion certificate — to the FAA or law enforcement upon request.[26] By December 2022, more than 385,000 recreational flyers completed TRUST certification subsequent to its inception in June 2021.[27]

[24] It is quite likely that many users are buying and experimenting with recreational small drones given the COVID-19 public health emergency and the substantial portion of the workers presently working from home. This trend may or may not continue once regular work patterns resume.
[25] See https://bit.ly/2pAYYxG.
[26] See https://bit.ly/3K3MF5Q for more details.
[27] It is important to note here that almost 63% of effective or active model/recreational aircraft users of sUAS (i.e., 612,220) are registered under TRUST in 2022. TRUST registration is only around a quarter (23%) with respect to base registered model/recreational users (i.e., 1.69 millions).

Trends in Commercial/Non-Model Aircraft and Forecasts Using Registrations vs. Effective/Active Fleet

Online registration for commercial/non-model small drones went into effect on April 1, 2016. Unlike recreational/model ownership, rules for commercial registration require owners to register each small drone, thus creating a one-to-one correspondence between registration and aircraft. During the period of January – December 2022, more than 105,000 commercial operators registered their new equipment. The pace of monthly registration, around 8,750, is higher than monthly registrations during 2021, which was approximately 8,500. The pace of new registrations is picking up speed slightly in comparison with 2021 and prior years. (From April 2016 – December 2021 there were roughly 8,850 new registrations per month). As the pace of recreational registration has increased somewhat, particularly last year, the pace of new registration for the commercial counterparts has followed suit, with almost 727,000 commercial drones cumulatively registered since April 2016.



For each month the registration has been available, over 4,600 new aircraft per month were registered until December 2017. This pace accelerated to 14,600 new registrations per month during 2018. During 2019, average monthly new registrations stood at approximately 10,100. During the year of 2020, average monthly registration dropped to 7,850, while during 2021, average monthly registrations jumped by 650 to around 8,500. During the last year of 2022, average monthly registration again jumped by 250 to around 8,750. The commercial small drone sector is dynamic and appears to be at an inflection point, demonstrating powerful stages of growth. Unlike the recreational small drone sector, the FAA anticipates that the growth rate in this sector will remain high over the next few years. This is primarily driven by the regulatory clarity that Part 107 continues to provide to industry. In particular, the operations over people final rule, published on December 28, 2020, is the latest incremental step towards further integration of small drones into the NAS. This final rule allows routine operations over people and routine operations at night under certain circumstances, and eliminates the need for individual Part 107 waivers.[28] Beginning in April 2021, routine nightly operations were approved under the conditions of remote pilot in command completing knowledge test or online recurrent training; and sUAS having lighted anti-collision visible for at least 3 statute miles.

Furthermore, the Remote ID rule was announced on December 28, 2020.[29] Upon adjudicating numerous comments from stakeholders, the final rule[30] was published in the Federal Register on January 15, 2021 with an original effective date of March 16, 2021. Corrections made to the rule and published in the Federal Register on March 10, 2021 delayed the effective date to April 21, 2021. Remote ID (i.e., digital license-plate) of remotely piloted aircraft is necessary to ensure public safety and efficiency of US airspace. The rule applies to all operators of small drones that require FAA registration (i.e., both recreational and Part 107). Remote ID provides airspace awareness to the FAA, national security agencies, law enforcement entities, and other government officials. In accordance with the requirements of the present rule, remotely piloted aircraft in flight are to provide, via broadcast, certain identification, location, and performance information that can be received by interested parties on the ground and by other airspace users.

There are three ways to comply with the remote ID rule: (a) operate a standard remote ID small drone broadcasting identification and location information of both the aircraft and control station; (b) operate a small drone with a remote ID broadcast module attached to it that broadcasts identification, location and take-off information; and (c) operate a small drone without remote ID at specific FAA-recognized identification areas (or FRIAs). As noted, almost all of the final rule on remote ID became effective on April 21, 2021. The subpart covering the process for FRIA applications from community-based organizations and educational institutions became effective on September 16, 2022. Drone manufacturer compliance with the final rule's requirements is set to become effective on September 16, 2022 as well. Finally, all drone pilots must meet the operating requirements of part 89 by September, 2023.[31] For most operators this will mean flying a Standard Remote ID Drone, equipping with a broadcast module, or flying at a FRIA.

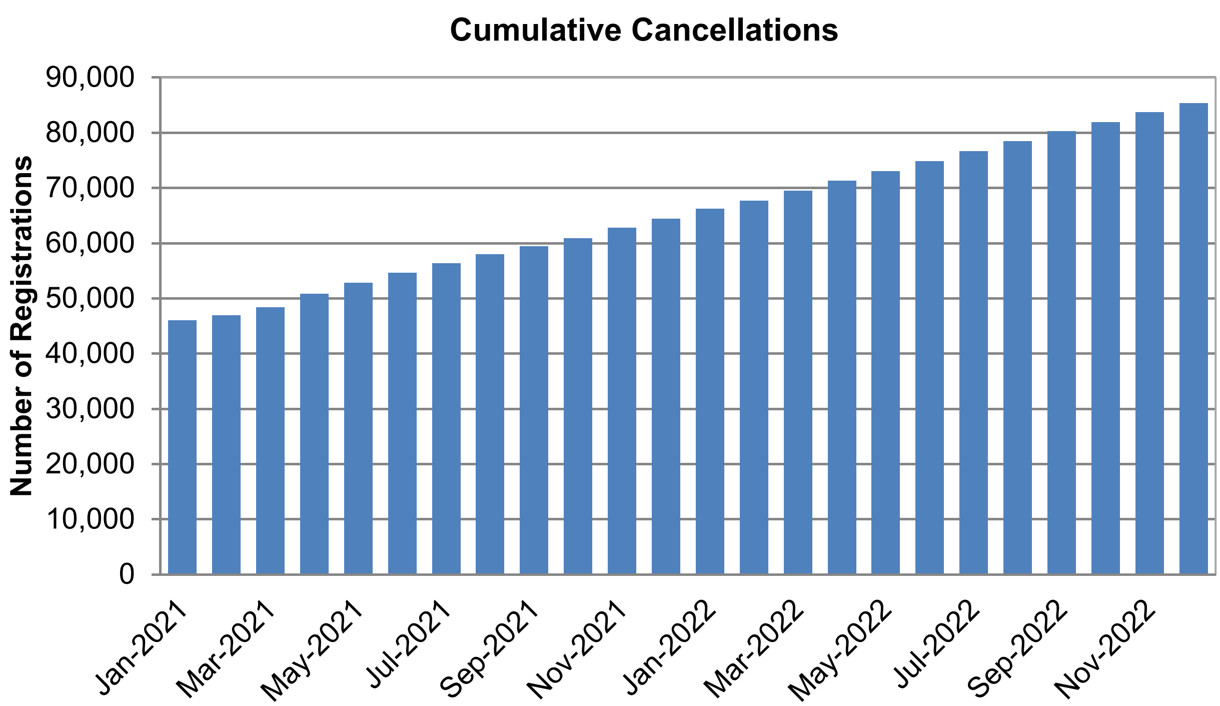
Together, these rules provide much-needed regulatory clarity and reduce the need for waivers under Part 107. With enhancement of operational efficiencies under increasingly well-defined concepts of operations (CONOPS)—which ensures safety and transparent information flow across the community—more and more commercial uses will become likely, fueling even further growth. Notably, as a central location for receiving all

[28] See https://bit.ly/3ZGumJC for more details.
[29] See https://bit.ly/3K9wSCv.
[30] See https://bit.ly/3MfupZS for more details.
[31] See https://bit.ly/3KaZQln for more details.

operational information, including registration, authorization, and accident report logs the DroneZone has helped further facilitate this growth.[32]

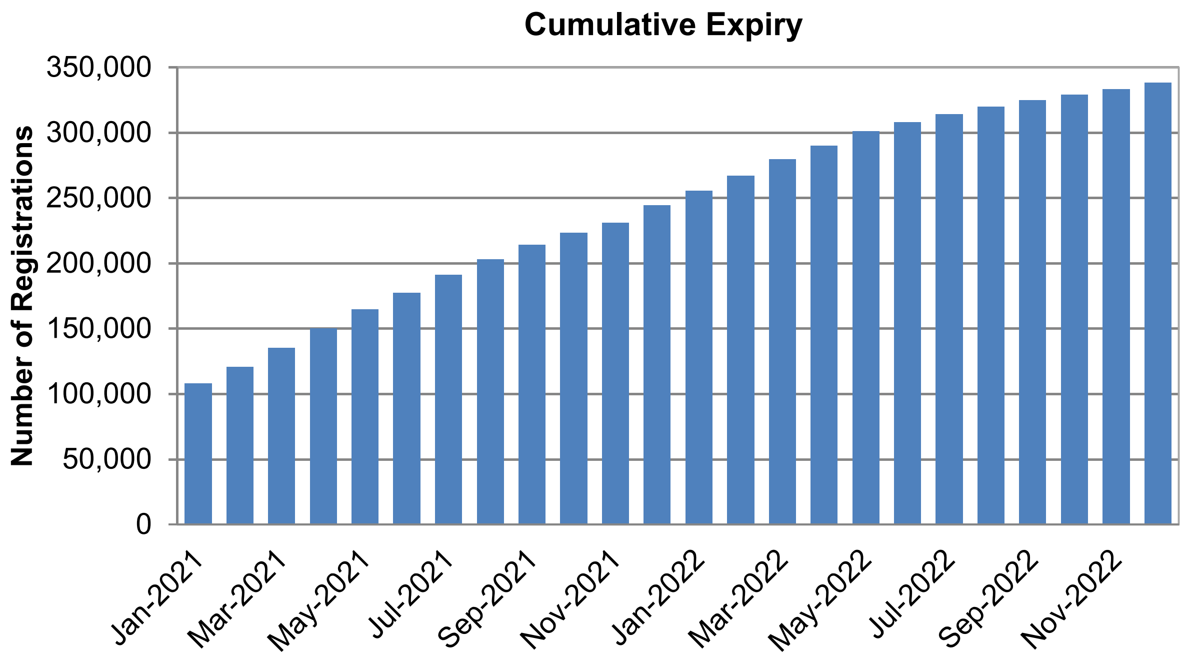
As noted in the preceding section, the beginning of the registration renewal afforded the FAA an opportunity to review Part 107 data; duplicates and unnecessary registrations were removed, and the registration database was made cleaner and more compact. As in the case of recreational/model aircraft, an examination of the data provides an opportunity to discern the effective/active fleet more accurately using the following five elements introduced earlier: Cancellations; Expiry; New; Renew; and Renew+. It is worth mentioning here that, prior to having access to these five elements, forecasts in the past were based only on new registration trends.

An average of 75,750 cancellations per month, on a cumulative basis, were reported during January – December 2022, as shown below. The trend in cumulative cancellations went up by over 20,000 from the year before. This is an average of approximately 1,743 new cancellations for each month of 2022.

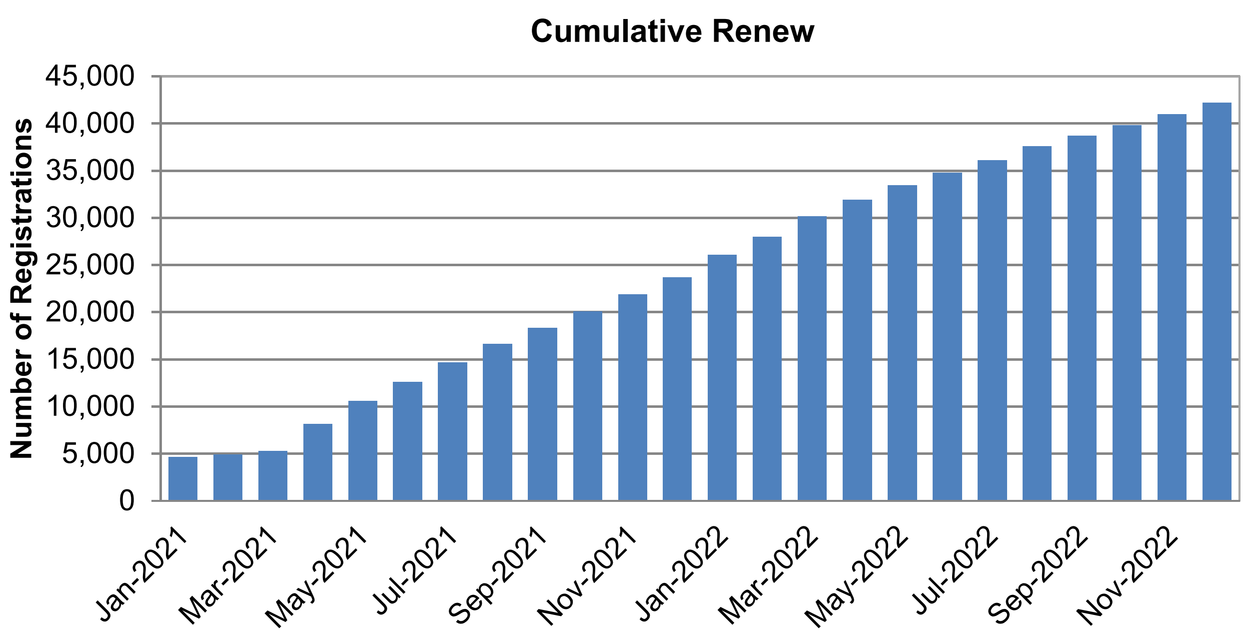


An average of 305,000 expirations per month was reported on a cumulative basis between January–December 2022 as shown below. (This equals approximately 7,812 new average expiries for each month during January–December 2022):

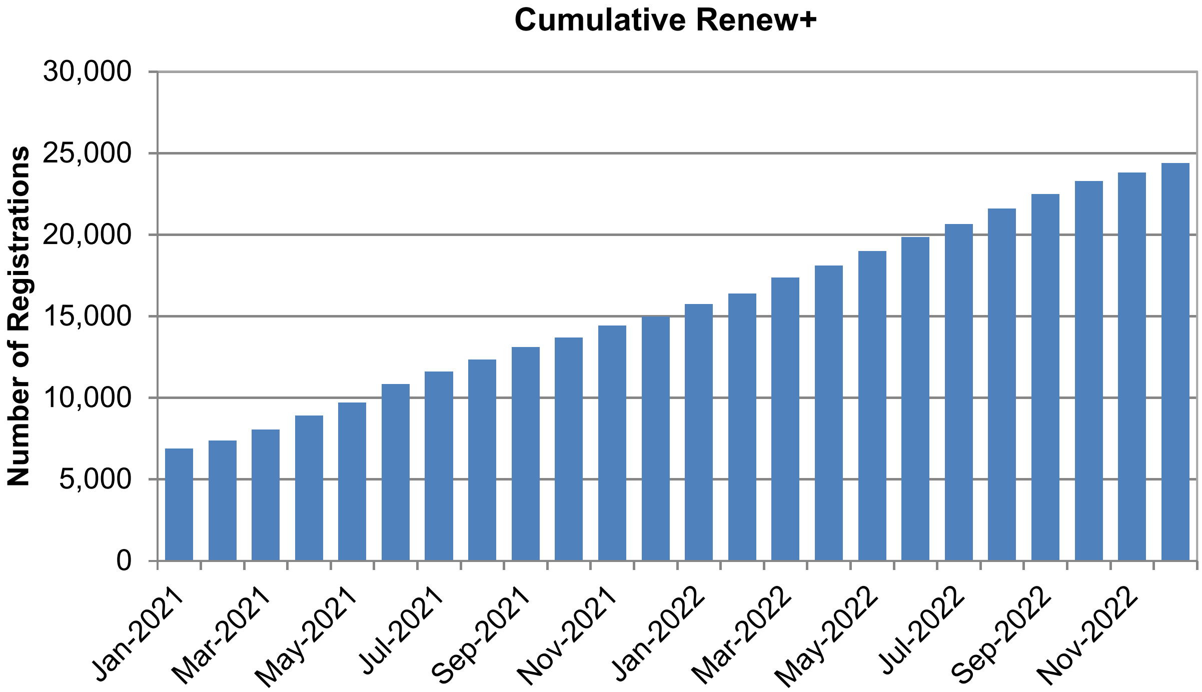
[32] See https://faadronezone.faa.gov/#/.



Renew or re-registration prior to expiry date accelerated, on average, to almost 35,000/month on a cumulative basis (or a two and half times increase from the year before) during January–December 2022 (or 1,543 new average renewals):



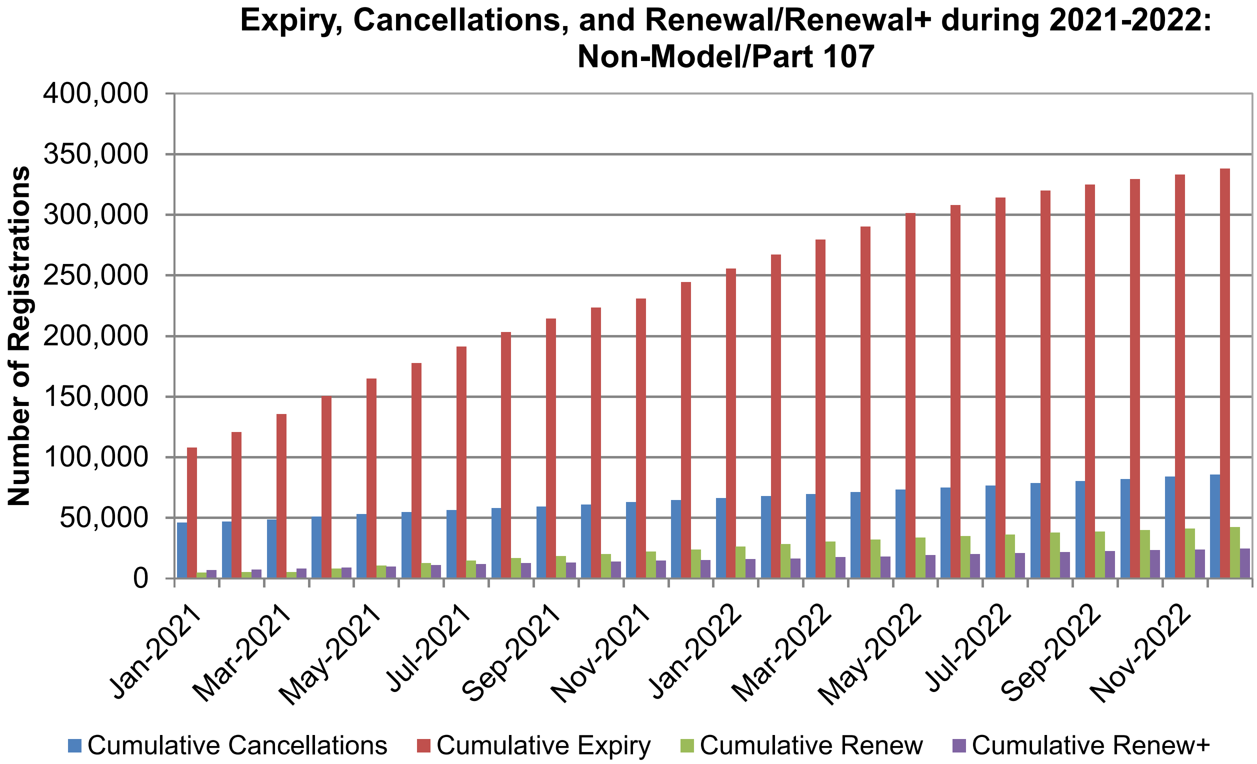
Similar to renewals, "Renew+" (i.e., re-registrations after expiry), logged at a rate much higher than last year to an average 20,216/month on a cumulative basis. This is an average of 784 new Renew+ each month during January–December 2022, as reported below:



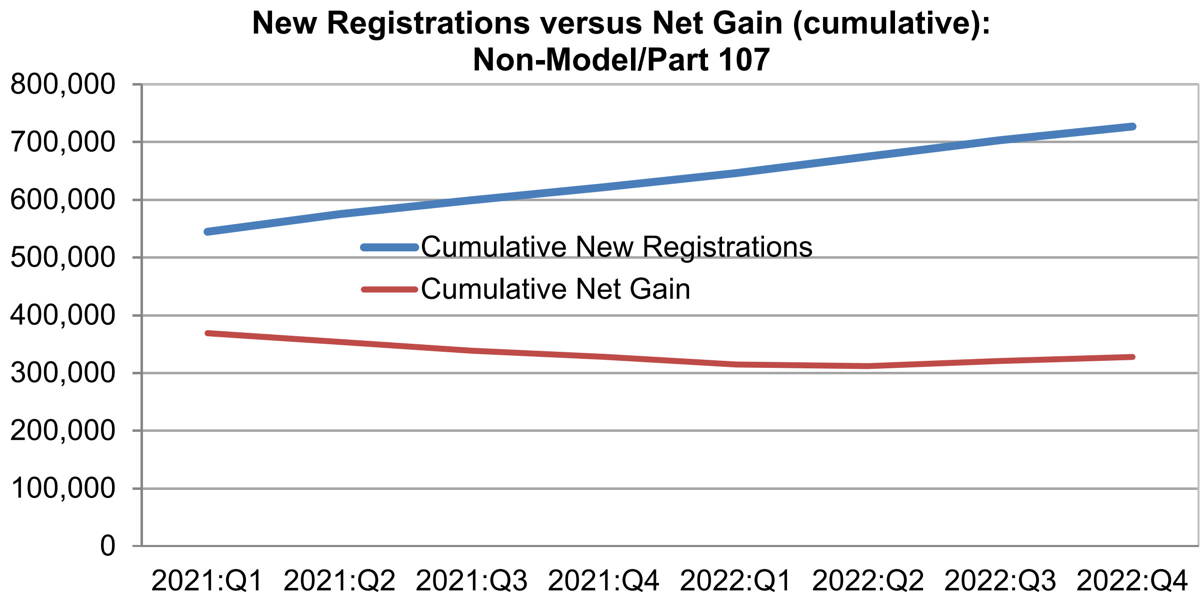
As in the case of recreational/model registrations, calculating active/effective registrations for a particular day requires calculating the "net gain/loss" of registrations for each preceding day and adding them with the particular day (i.e. calculating the running sum).

Using the formulation described in the example in the preceding section, we can derive the net gain/loss for Part 107 data as well.

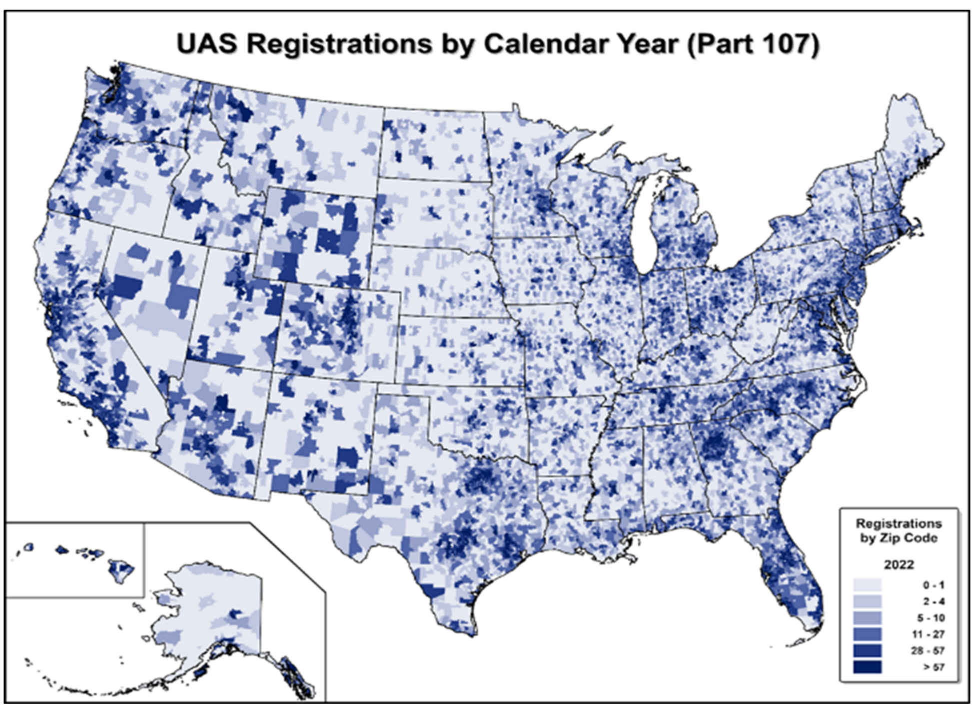
A summary of the above 4 charts is provided in below to relate the relative contributions of cancellations, expiry, renew and renew+:



A comparison chart capturing the difference between cumulative new registrations vs. effective/active registrations using net gain/loss for Part 107 registration is provided in below:



As in the case of recreational drone ownership, commercial small drones are distributed across the country. A spatial distribution of equipment registration by zip codes (using data for December 2022) demonstrates that commercial small drones are distributed throughout the country, with denser activity mapping closely against the economic or commercial activities of the geographical areas.



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Last year, the FAA forecasted that the commercial drone sector would include approximately 699,000 small drones in 2022 in base case, a growth rate exceeding 12% over the year before (2021). Actual data came in around 727,000 aircraft by the end of 2022. Our forecast of commercial small drones last year thus undershot (around -4%) for 2022 (or 726,936 actual aircraft vs 699,379 projected aircraft). In low case, FAA forecasted last year 292,000 units to be effective/active for the year 2022; but in reality, the number came to be around 328,000 thus undershooting the lower case by -11%. Forecasting in a time of tremendous uncertainty is indeed challenging, especially given the economic slowdown during COVID-19 and its impact on the drone sector. The commercial small drone sector's fast growth and adjustments during the pandemic demonstrate that fact. Nevertheless, our forecast errors for both recreation and commercial small drones appear to be within the bounds of reasonableness.

Total Commercial/Non-Model Fleet (Thousand sUAS Units)

Fiscal Year	Low*	Base**	High**
Historical			
2022	328	727	727
Forecast			
2023	349	805	807
2024	364	862	867
2025	373	904	915
2026	378	933	966
2027	382	955	1015

*: Effective/Active fleet counts;

**: New registration counts based on fleet counts;

The FAA uses the trends observed in registration during previous years, calculation of net gain/loss, information from the survey conducted in 2018 and again this year, a review of available industry forecasts/workshops and past FAA Drone Symposiums, and internal research together with market/industry and academic research undertaken by ASSURE, an FAA Center of Excellence (or COE).[33] Using these and with the help of a time series model fitted onto the monthly data, the FAA forecasts that the commercial drone fleet will likely (i.e., base scenario) be at around 955,000 by 2027. This is 1.31 times larger than the current number of new commercial small drones.[34]

[33] See https://bit.ly/432Gxn5.

[34] Last year, the ratio of end-year forecast to base-year forecast was 1.38-times. That is, the FAA forecasted end-year to be 1.38 time base year's (2021) numbers in 5-year (2026). Higher forecasts are often the result of improved regula-

Using low or effective/active fleet, the FAA forecasts an expansion of the small drone fleet by 54,000, 1.16 times larger than the currently calculated effective/active fleet of around 328,000 units.[35] As the present base (i.e., the cumulative total) increases, the FAA anticipates the growth rate of the sector will slow down over time, and the effective/active fleet will likely catch up with the growth trajectory of new registrations. Nevertheless, the sector will be much larger than what was understood only a few years earlier.

In order to understand the growth trajectory of the sector better, this report divides the commercial drone sector into two types of small drone aircraft: consumer grade and professional grade. Consumer-grade commercial drones have a wide range of prices, below US $10,000 with an average unit price of approximately $2,500. The professional grade, on the other hand, is typically priced above US $10,000 with an average unit price assumed to be around $25,000.[36] For both consumer-grade and professional-grade drones, the average price has fallen over time, particularly over the last few years. Currently, the consumer grade dominates the commercial drone sector, with a market share approaching 90%. However, as the sector matures and the industry begins to consolidate, the share of consumer grade commercial drones is likely to decline, though it will still be dominant.

Unlike its recreational small drone counterpart, it is extremely difficult to put a floor on the growth of the commercial small drone sector due to its composition (i.e., consumer vs. professional grades) and the varying business opportunities and growth paths. As commercial small drones become operationally more efficient and safe, battery life expands, and integration continues (e.g., recent final rule involving operations over people; and remote ID), new business models will begin to develop, thus enhancing robust supply-side responses. These responses, in turn, will pull demand forces (e.g., consumer responses to receiving commercial packages, routine blood delivery to hospitals, and search-and-rescue operations) that are somewhat latent and in the experimental stage at present. Unlike a developed sector such as passenger air transportation, it is impossible to put a marker on "intrinsic demand" (or core demand) primarily driven by economic and demographic factors underlying this sector. Nevertheless, in this year's forecast the FAA makes a provisional attempt to provide a "low" side for now, essentially capturing the intrinsic demand and making use of the calculation of effective/active fleet. In addition, we provide the likely or base scenario, together with the enormous potential embodied in the "high" scenarios, representing cumulative annual growth rates of 6% and 7%, respectively. As noted earlier, low scenarios are driven by two positive factors (i.e., new registration and renew+) and two negative factors (i.e., cancellations and expiry). Average annual growth rate corresponding to the low scenario is determined by the combined effect of both positive and negative factors; and presently calculated to be approximately 3.1%. This is much smaller than both base (5.6%) and high scenarios

tory environments, as noted below, and environments following the process of rule-making evaluation (See fn. #30-33 for these).

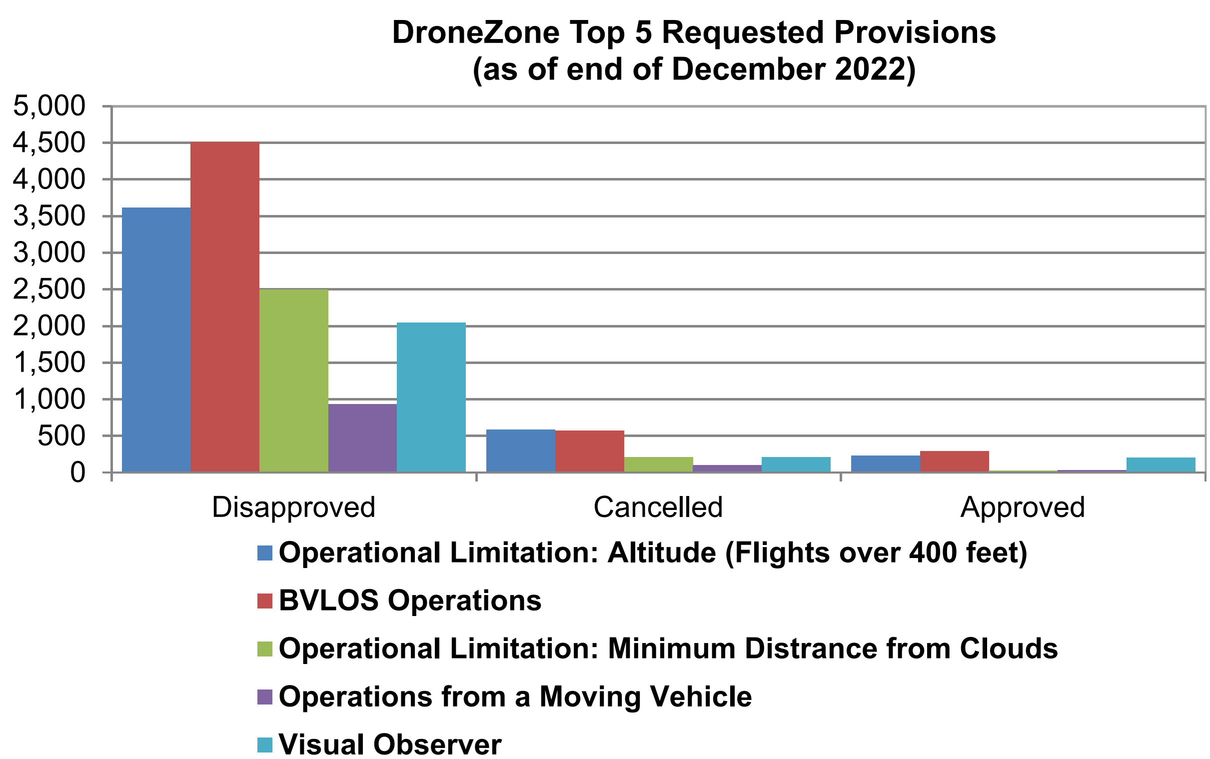
[35] This is driven by the combined effects of projected underlying growth rates of cancellations, expiry, new registrations, and renewals.

[36] Because of this wide range in prices between types of small drones in commercial activities, start-up costs for a business may vary between $2,500 and $25,000.

(6.9%) and this is because effective/active count is driven to catch up with the new registrations trend.[37]

Commercial small drones are currently used for numerous purposes. As the sector grows, the FAA anticipates there will be many more uses for, and much more use of, commercial small drones. This is increasingly evident, for example, from the continuing implementation of UAS traffic management system (UTM),[38] successful implementation of the UAS Integration Pilot Program (IPP),[39] and continuation in BEYOND.[40]

As Part 107 sub-provisions are relaxed, it is important to identify trends in commercial small drone via analysis of the remaining waiver applications granted to small drone operators. Both the magnitude and relative composition of waiver types may indicate the direction of the commercial small drone sector as a whole. A breakdown of the waiver requests (i.e., approved, disapproved or denied, and cancelled due to lack of information primarily or withdrawn) aggregated for January-December 2022 is shown in the chart below:



[37] See prior footnotes for similar explanation pertaining to effective/active count for recreational registration.
[38] See https://bit.ly/3KucgX4
[39] See https://bit.ly/2O4tzPP for more details.
[40] See https://bit.ly/3nKAOIK. We provided a detailed analysis of BEYOND program in last year's document.

Beyond the daytime operation and operations over people that are presently allowed under existing Part 107 rules, expanding applications further requires waivers, to a large extent, for numerous other operations involving BVLOS, flying over 400' AGL, etc. BVLOS waiver requests (around 14% of total requests as like the year before) and limitations on altitude (around 14% of total requests; an increase of 3% from last year) accounting for almost 28% of all waiver requests submitted. Waiver requests are granted at a rate of 23% and 30% (i.e., approvals in comparison to submitted requests) for flying over 400' AGL and BVLOS, respectively.

Waivers are issued to facilitate business activities by small drones while preparing for the next round of regulations that will enable routine more complex drone operations. Now that night operations and operations over people have been finalized,[41] amending Title 14 of the Code of Federal Regulations Part 107 (14 CFR Part 107) by permitting the routine operation of small drones at night[42] or over people under certain conditions,[43] the Agency is turning its focus to long term solutions that will eventually enable routine BVLOS fights without waivers.[44] Analysis of the waiver applications allows the FAA to understand industry needs and priorities, one of many metrics essential for understanding trends of the sector and projecting the growth trajectory and course corrections over time.

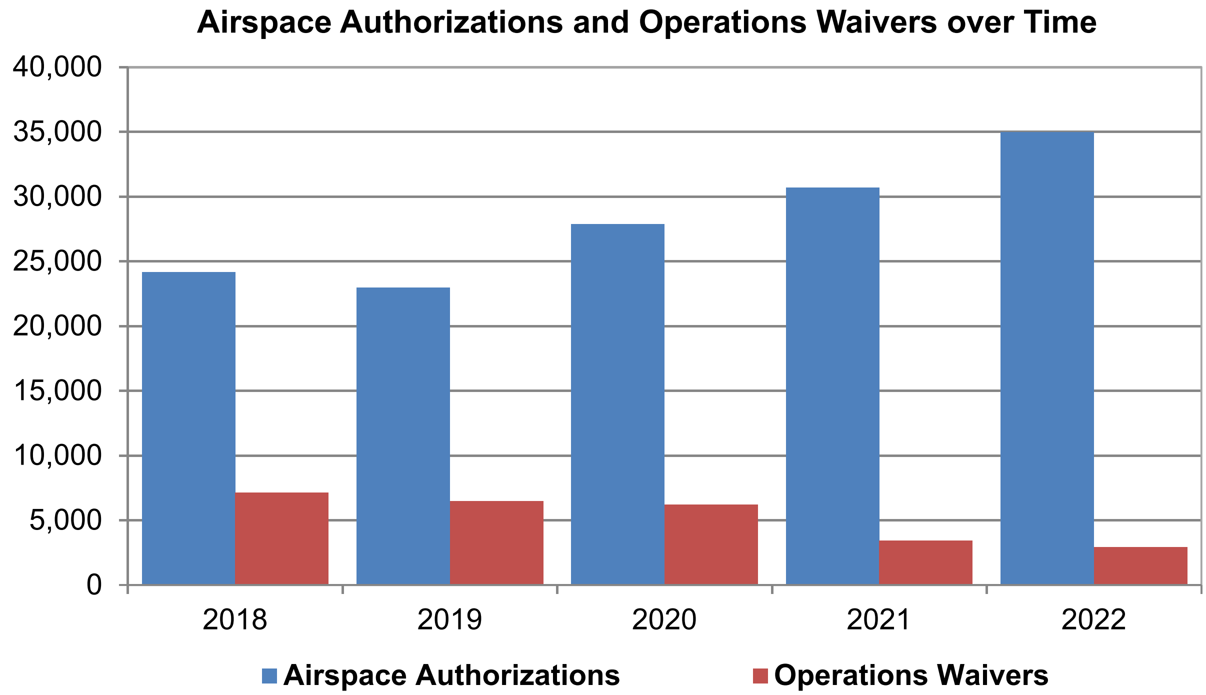
Airspace authorizations have been growing over time as shown in the chart below. While airspace authorizations have been growing consistently since 2019, at an average annual rate exceeding 10%, operations waivers have been declining over the years. Nearly 60% of airspace authorizations and waiver requests have been approved for controlled airspace at the end of December 2022.

[41] The rule was published in the Federal Register on January 15, 2021. Corrections to the final rule were published in the Federal Register on March 10, 2021, delaying the effective date from March 16, 2021 to April 21, 2021 [See https://bit.ly/3ztaC1w].

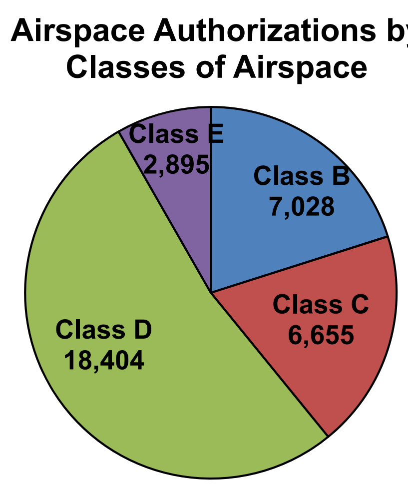
[42] See § 107.29. An operation at night was defined as an operation conducted between the end of evening civil twilight and the beginning of morning civil twilight, as published in the Air Almanac, converted to local time (ibid).

[43] See § 107.39. An operation over people was established as one in which a small remotely piloted aircraft passes over any part of any person who is not directly participating in the operation and who is not located under a covered structure or inside a stationary vehicle.

[44] On June 9, 2021, the FAA initiated an Aviation Rulemaking Committee (ARC) to facilitate BVLOS in the NAS. [See https://bit.ly/3Kduevw for details.] On March 10, 2022, UAS BVLOS ARC provided recommendations to the FAA for performance-based regulatory requirements to normalize safe, scalable, economically viable, and environmentally advantageous BVLOS drone operations that are not under positive air traffic control (ATC) [see https://bit.ly/3Mis6Wc for the final report]



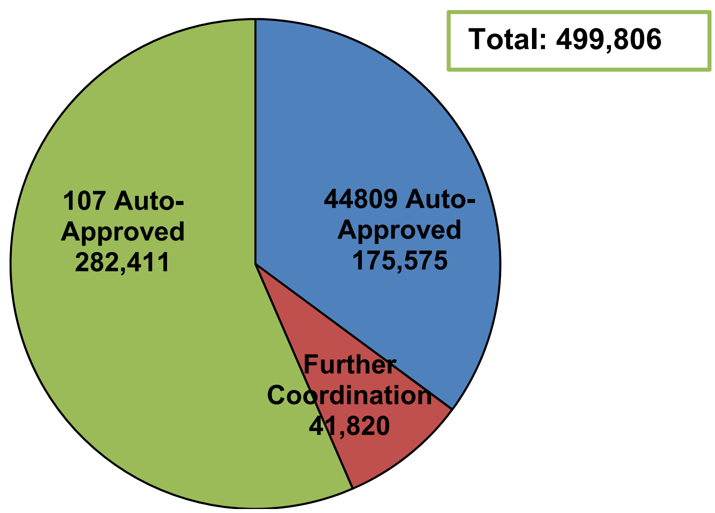
While over half continue to be for Class D airspace (i.e., smaller airports with control towers), other classes were also requested, granted and regularly flown as reported in the chart below:



Finally, LAANC has been routinely providing auto-approval since its inception in May 2017, and now covers 545 airports with UAS

Facility Maps or UASFM[45] enabled at 740 airports. It has provided over 1.465 million approvals: 809,727 auto-approvals for airspace access requests from Part 107 users, and 514,326 requests from recreational operators as defined by 49 U.S.C. §44809[46] and sending 141,717 for further coordination.[47] Approvals thus total 1,465,770, around 465,000 more since this time last year. LAANC authorizations are facilitated by the use of UASFM that provide maximum allowed altitudes around airports where the FAA may authorize Part 107 UAS operations without additional safety analysis.[48] The UAS facility maps are used to inform requests for Part 107 airspace authorizations and waivers in controlled airspace.

LAANC Authorization Types



2022 Survey and Preliminary Results

The FAA has strived to develop a better understanding of the flight characteristics and operations of sUAS across the United States. Unlike commercial aviation, which has statutory reporting requirements, sUAS operate mostly outside of airports or other fixed infrastructure and are free to operate without reporting activities to aviation authorities while in uncontrolled space. As such, little is known about the general operations of sUAS, which has hindered the FAA efforts to effectively integrate sUAS into the NAS.

In an attempt to improve the FAA's understanding of sUAS activities, following on earlier similar effort, the FAA has developed and conducted a survey of sUAS operators. This Office of Management and Budget (OMB) approved survey information collection started with a baseline and pre-tests for sUAS activities in 2021 and the survey for

45 See https://bit.ly/3KwWOtj.
46 §44809 is strictly for recreational uses. See https://bit.ly/3zvW6pL.
47 Activity reported below is for the calendar year of 2022: January 1-December 2022.
48 See https://bit.ly/3K2hFmA.

sUAS activity in 2022. The survey design is a stratified, random sample of sUAS operators with type of operator, recreational or Part 107, and geography, U.S. County, as the strata. The survey frame was constructed from the recreational sUAS and the Part 107 registries.[49] A total 65,734 invitations were sent to sUAS registrants: 41,624 recreational registrants and 24,110 Part 107 registrants, located in over 2,100 U.S. counties and constituting roughly 30% of active sUAS registrants.[50] The survey for 2022 sUAS activity was opened on December 1st, 2022 and closed on February 1st, 2023. Follow-up reminder emails were sent out periodically based on the population until the final week of the 2022 survey.

Overall, 30.3% of invited registrants responded to the 2022 survey. Recreational registrants were slightly more likely to respond with a 34% response rate. This was up sharply from the 24% response rate in the 2021 survey baseline.[51] Part 107 registrants were relatively less likely to respond with a 23% response rate. This was only a marginal improvement from the 22% response rate of the 2021 baseline survey. Several improvements in the survey campaign contributed to the improved response rate, including an improved survey frame, better design of reminder emails, and improved coordination the FAA sUAS help desk. However, improved community knowledge of the FAA's survey of sUAS operators from conducting the 2021 baseline survey was likely part of the improvement as well. Of the invited registrants who did not respond, 4.6% had unreachable email addresses and an additional 4.6% had opted out of receiving emails from Survey Monkey while the reasons for the remainder of the non-responses are unknown.[52]

The Survey of sUAS operators used a questionnaire distributed by Survey Monkey to collect responses from selected, registered sUAS operators.[53] The questionnaire consisted of 6 required questions as well as 71 optional, administrative, or additional questions based on the respondents' answers or

[49] As noted earlier, 49 U.S. Code § 44809 requires recreational sUAS aircraft systems operators to register with the FAA. In addition, 14 CFR Part 107 requires non-recreational operators to register with the FAA. UAS operators must register with one of these registers at FAA's https://bit.ly/41328Kr and paper forms are no longer available.

[50] The survey design is a stratified random sample of registered operators. The strata are the registries and the U.S. county in which the operator is domiciled. Each county had 30 registrants randomly selected to receive an invitation to the survey. If the number of registrants in the county are fewer than 30, all registrants in the county were sent an invitation. For more information, a survey supplement is available upon request.

[51] The baseline survey was an initial survey design and questionnaire to establish a baseline understanding of the UAS community. The baseline was used to determine if test surveys, controlled deviations in the survey design and questionnaire from the baseline design, had a significant effect on responses to the questionnaires. More information is available via survey supplement.

[52] Survey Monkey allows individuals to place their email addresses on a no-contact list. When Survey Monkey distributes email invitations through their system, emails on the no-contact list are filtered out and noted for their survey administrators. More information is available via survey supplement.

[53] Survey Monkey [see https://bit.ly/3McSikL] is approved by the Government Services Administration (GSA) and provides a fast and cost effective method for designing, deploying, and organizing questionnaire. Given the internet-based registration for sUAS operators, an internet-based questionnaire, such as Survey Monkey, was best suited for this population. More information is available via survey supplement.

the registry in which the respondent was active.[54] Given that many operators use their sUAS for several purposes, selected Part 107 registrants were asked to report only on non-recreational activity while selected recreational registrants were asked to report only on recreational activity. All selected registrants were given the opportunity to participate in the survey by completing the questionnaire, opt out of the current year's survey, or be permanently removed from future survey invitation lists.[55] Of those that responded to the invitation email, 94% agreed to participate, 3% opted out of the survey for 2022, and 3% requested that the FAA permanently remove them from the FAA's survey list.[56]

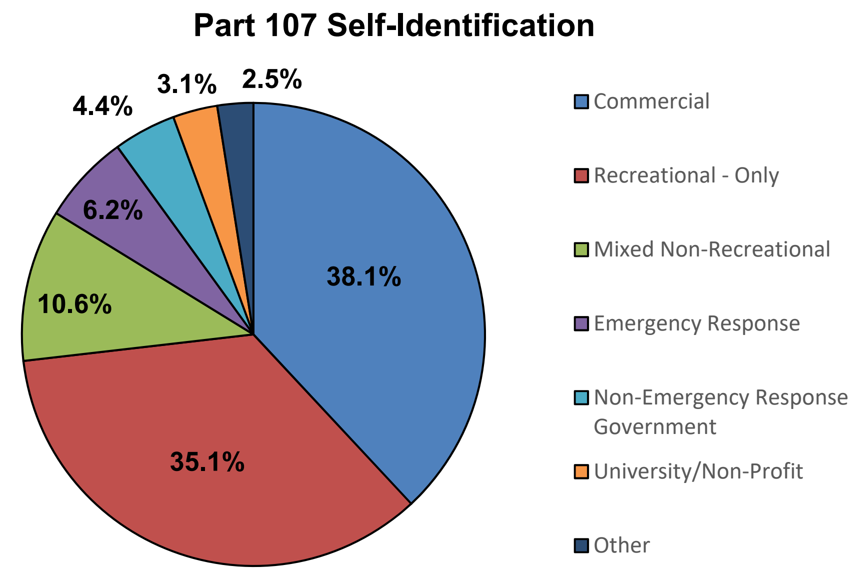
One of the questions was a self-report on the type of sUAS operator the respondent considered themselves. Respondents were given the multiple-selection options of business, emergency response, non-emergency government, university/non-profit, and recreational as well as a fill-in "other" category. For respondents from the recreational registry, 98.1% of the respondent self-identified as recreational operators. Of those who self-identified as recreational operators, 5.8% also selected at least one non-recreational category. Of the 1.9% of operators who did not self-identify as recreational operators, 70% reported uses better suited for Part 107 and the 30% were protests or misinterpretations of the word "recreational".

For respondents from the Part 107 registry, over a third of respondents (35.1%) identified as recreational only operators. Just under two-thirds (62.4%) of respondents reported either business, emergency response, non-emergency government, or university/non-profit uses. Of those identifying as a non-recreational operator, 61% reported operating their sUAS for only business or for-hire reasons while operators reporting only emergency response, university/nonprofit, or non-emergency government made up 10%, 7%, and 5%, respectively. The remaining 17% of non-recreational operators reported a combination of the 4 non-recreational options. The remaining 2.5% of all respondents selected only the "other" option with either a protest or misinterpretation of the other categories.

[54] Only 6 questions in the questionnaire were required. Of the remaining 71 questions, 32 were optional, 5 were follow up questions, 3 were only for part-107 registrants, 8 were for operators identifying as emergency response, 15 were optional comments boxes, and 8 were administrative. More information is available in survey supplement.

[55] Invited registrants had several means of opting out of the survey, including opting out through Survey Monkey, opting out of the current year's survey in the questionnaire, or removing their email from the FAA survey list in the questionnaire. More information is available in survey supplement.

[56] Within the questionnaire, 548 recreational and 153 part-107 registrants opted out of the 2022 Survey of sUAS operators while 424 recreational and 195 part-107 registrants opted out of any future surveys. Even though these registrants opened the survey and answered the opt-out questions, they were counted as a non-response.



The self-identification question suggests that the vast majority of sUAS operators who register in the recreational registry are using their sUAS for personal enjoyment. However, Part 107 registrants have more diverse uses for their aircraft. With more than a third of Part 107 registrants using their aircraft for personal enjoyment, defining Part 107 operators as non-recreational or non-hobby is likely not completely accurate.

All respondents, regardless of the registry in which they registered, were asked about the average number of flights, defined as a takeoff and a subsequent landing, and the average duration of each flight. Respondents from the recreational registry reported 17 flight per month on average across the United States. However, the median was only 3 flights per month, suggesting the majority of recreational operators were only using their sUAS on one weekend a month while a smaller group of enthusiasts are operating multiple fights daily.

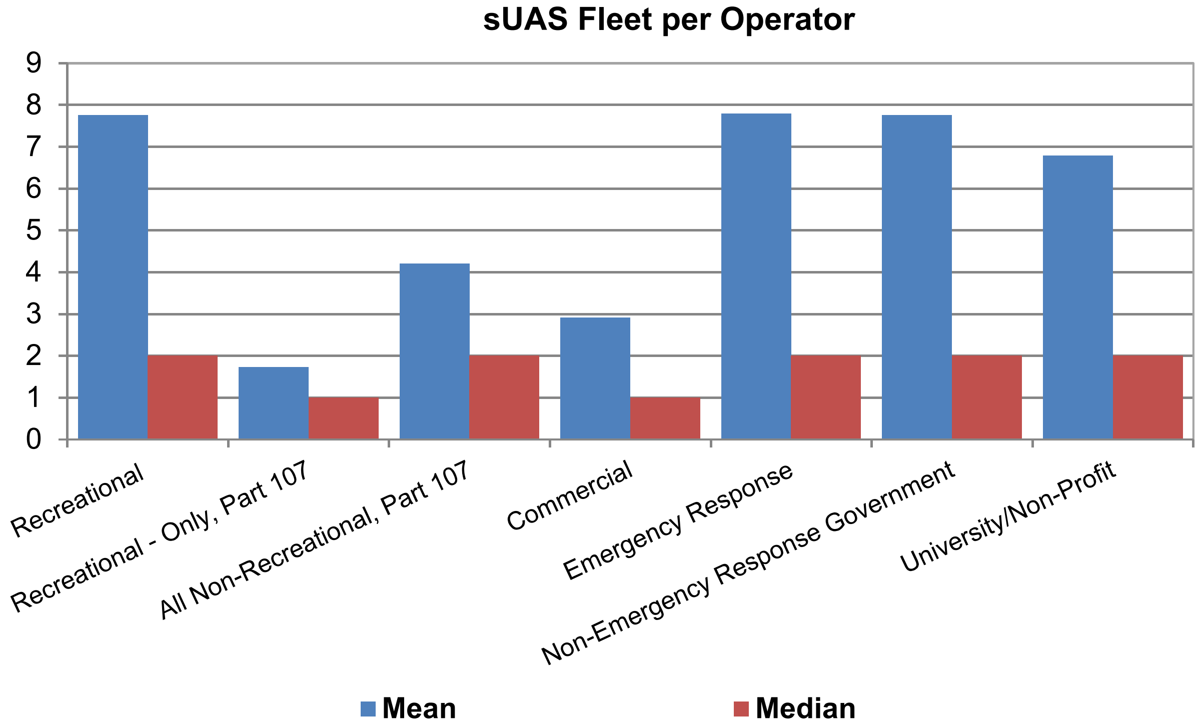
The average duration of each flight for recreational registrants is 24.7 minutes, but the median duration is only 12 minutes.57 In closer consideration of these responses, we find that 0.9% of respondents reported more than 60 minutes for the duration of each flight, which is generally the flight time limitation for most commercially available sUAS batteries, and this group reported an average of almost 20 hours per flight. This suggests that some respondents may have misunderstood the question and assumed the question was regarding total time operating their sUAS in a month. When this population is removed from the statistics, the average time per flight is 14.1 minutes, which is much closer to the median of 12 minutes. Combining the reported flights and durations for each responded and removing the respondents with flight durations greater than 60 minutes, we find an average total flying time of 2.9 hour per month per operator but only 45 minutes for the median operator.

[57] These statistics reflect the active fleet of recreational UAS operators. As such, all operators who reported that they did not operate a sUAS aircraft in 2022 were removed from the data.

Recreational registrants reported an average of over 7 sUAS per operator with the median operator owning 2 aircraft. Three quarters of each operators' fleet were operated on average in 2022, but the median operator utilized their entire fleet. The fleet and flight behavior reported suggest that recreational registrants fall into two categories: novices and enthusiasts. The novices comprise the majority of the recreational registrants, tend to have one or two aircraft, operate one or both regularly, and only one weekend a month. Conversely, enthusiasts tend to have many more aircraft, operate only a portion of their large fleet, and fly regularly throughout the month.

The flight behavior for Part 107 operators is complicated by the diversity of the population. As discussed above, over a third of registered Part 107 operators are recreational only operators. These recreational-only Part 107 operators represent a distinct category of operator and may have distinct flight characteristics. In the construction of the questionnaire, the FAA wanted to separate Part 107 operations from recreational operations since many Part 107 registrants are also registered as recreational operators. Thus, the questionnaire asked Part 107 registrants to report only non-recreational flight activity. As such, almost all of the recreational-only, Part 107 registrants reported zero for their non-recreational flights and durations. However, a portion of the Part 107 registrants were selected to answer an additional questions about the number of flights operated in each month regardless of whether it was for recreational or non-recreational uses. Using the answers to this additional question, recreational-only, Part 107 operators flew 2.3 flights per month in general with a median of 1 flight per month.

Recreational-only Part 107 registrants reported an average of just under 2 sUAS aircraft per operator with the median operator owning only 1 aircraft. Given the fleet and flight profile of this group, they seem to be more akin to novice operators in the recreational registry than the enthusiast. This suggests that there could be some confusion among new operators regarding which registry is more appropriate to their operations. The counter argument is that this portion of recreational operators are enthusiasts who are seeking expanded flying privileges with Part 107 waivers. However, only 2.3% of this group reported an intention to seek a waiver compared to 20.6% for non-recreational operators. As such, the recreational-only, Part 107 operators could be better served by the section-44809 recreational registry than the Part 107 registry.



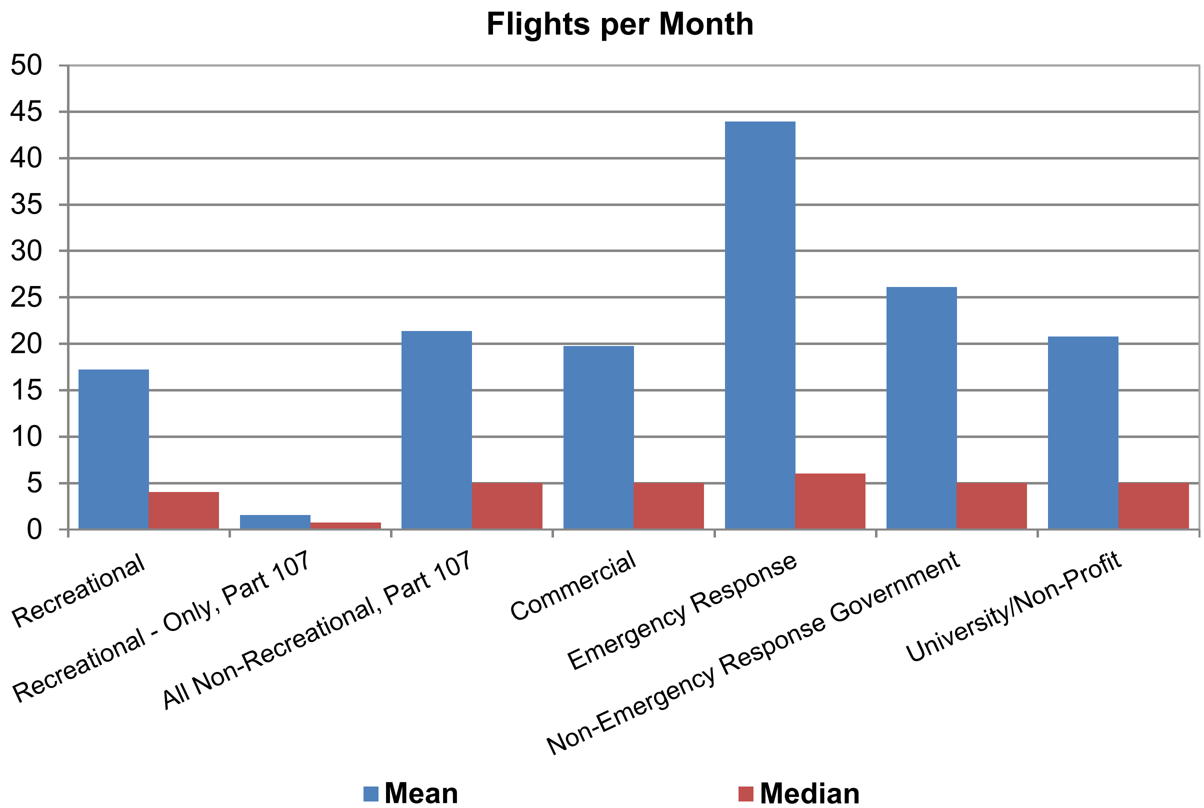
Part 107 operators engaged in non-recreational activities flew 21 flights on average per month with a median of 5 flights.58 However, the number of flights changed based on how the respondent self-identified. Respondents who identified as commercial operators flew slightly fewer times per month compared to all non-recreational operators at 20 flights, but the median operator's flights are the same. Respondents who identified as emergency response, non-emergency government, or university/nonprofit reported an average of 44, 26, and 20 flights with a median of 6, 5, and 4, respectively. This suggests that emergency-response operators are the most active of Part 107 registrants and university or nonprofit operators are the least active.

Non-recreational operators flew 26.3 minutes per flight with a median of 20 minutes. Respondents who identified as commercial operators reported slightly shorter flights of 25.4 minutes on average but with the same median. Respondents identifying as emergency response, non-emergency government, and university/nonprofit reported flight durations of 35.9, 22.5, and 21.9 minutes on average, respectively, but all have the same median as all non-recreational operators.

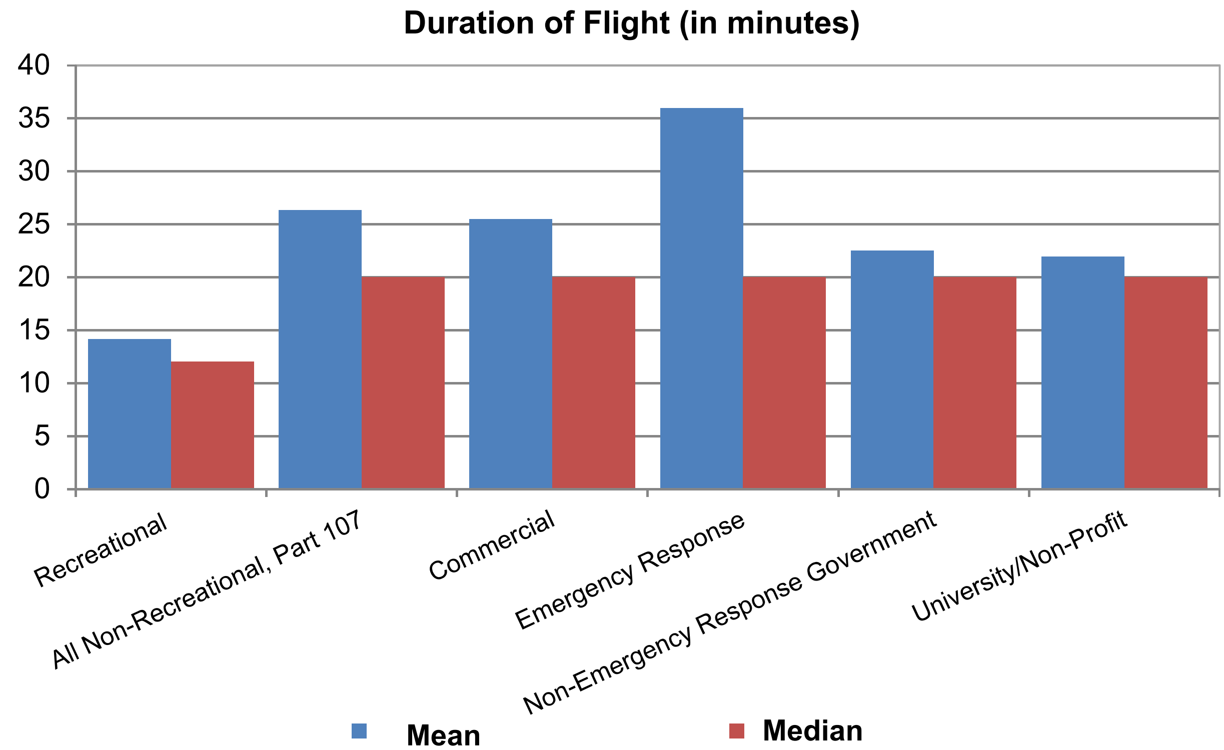
In general, non-recreational operators spent a total of 8.4 hours per month operating their sUAS for non-recreational purposes. However, the median was far less at just an hour and a half. Operators who identified as commercial operators flew 7.1 hours per month

[58] These statistics reflect the active fleet of recreational UAS operators. As such, all operators who reported that they did not operate a sUAS aircraft in 2022 were removed from the data.

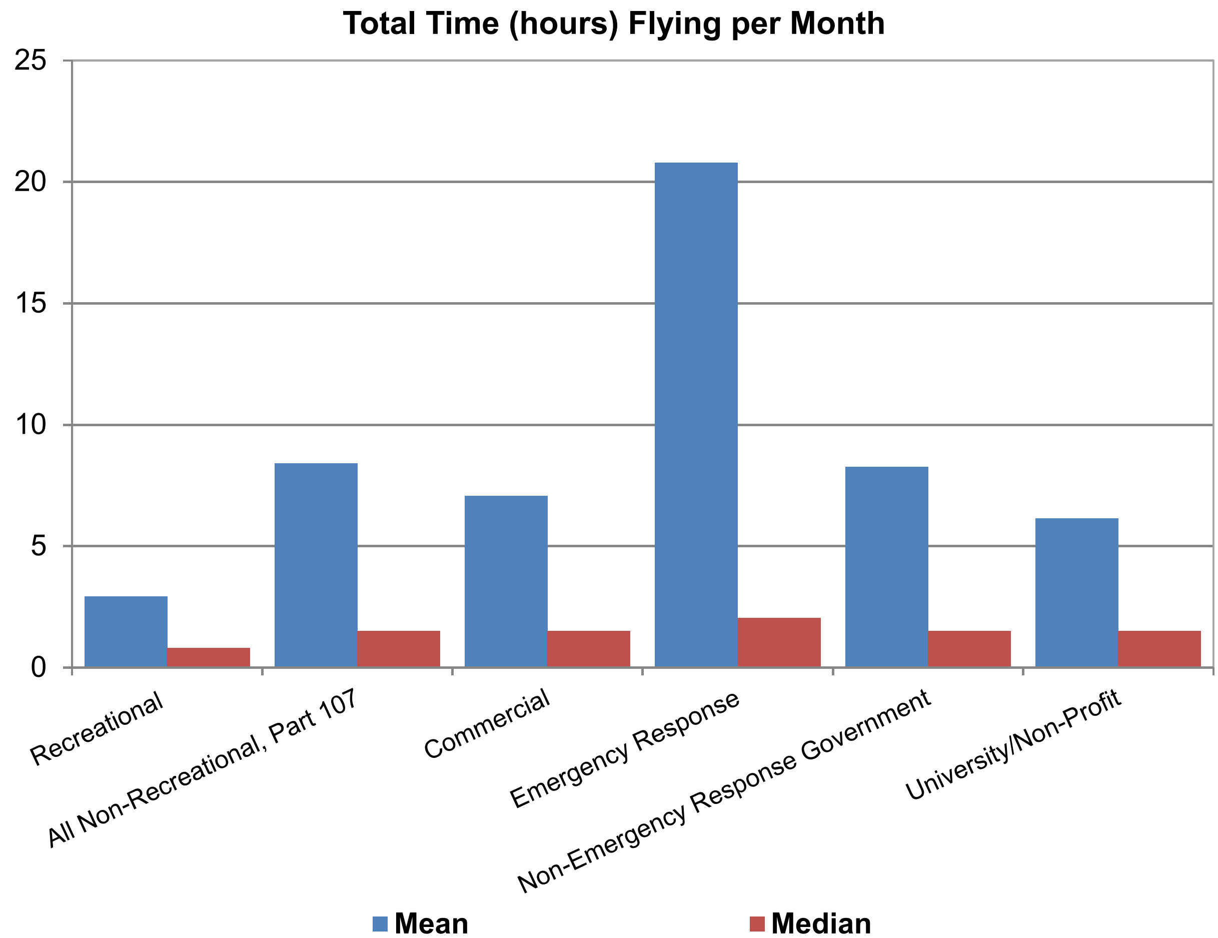
on average, less than the general population of non-recreational operators but shared the same median. Emergency-response and non-emergency government have a greater averages total operating time compared to the general population of non-recreational operators with an average of 20.8 and 8.3 hours, respectively, but only emergency-response operators had a median greater than the all non-recreational operators at 2 hours. University/nonprofit operators flew less than the general population of non-recreational operators on average at only 6.1 hours but with the same median.



Non-recreational registrants reported having an average of almost 6 sUAS aircraft with the median operator owning 2 aircraft. Similar to recreational registrants, the median operator flew all aircraft in their fleet in 2022, but on average, operators only flew 82% of their fleet. Commercial operators tended to have slightly smaller fleets at 4 aircraft on average, but a median 2 aircraft, similar to all non-recreational operators. Emergency response and university/nonprofit operators had significantly larger fleets than the general non-recreational operators with an average of 10 sUAS aircraft and the median operator having 3 aircrafts for both groups. Although their fleets are similar, emergency response operators utilized 95% of their fleet in 2022 on average, the highest among the groups, while university/nonprofit operators utilized only 72% of their fleet in 2022 on average, the lowest among the groups. Non-emergency government operators reported owning 7 aircraft and operating 90% on average with the median operator owning and operating 2 aircraft in 2022.



Non-recreational operators report more intensive flight behavior compared to recreational registrants or recreational-only, Part 107 registrants, which conforms to the notion that professional operators are spending more time during the week operating their sUAS. Universities and nonprofits have the lowest time operating, which could reflect the experimental nature of the sUAS aircraft flown by this group. Emergency-response operators tend to report the most time operating, which suggests a maturing of this segment of Part 107 registrants. However, the large difference between the average and the median suggests that Part 107 registrants are bifurcated into a small number of professional operators and a large number of part-time operators.



The fleet responses from the non-recreational, Part 107 operators along with the flight responses suggest that these groups may be at different stages of their lifecycle and occupy different niches within the sUAS industry. Both emergency-response and non-emergency, government operators tend to have larger fleets and operate their aircraft more often than other non-recreational operators, indicating more professional and organized programs. University/nonprofit operators have larger fleets than the average non-recreational operator, but the utilization of these aircraft is lower. This suggests that universities and nonprofits are experimenting with sUAS more than using sUAS for routine operations. Commercial operators tend to have the smallest fleets and the fewest operations per month compared to non-recreational operators as a whole, which suggests a less mature segment of non-recreational sUAS market. However, the large difference between the average and the median indicates that there are many small entrepreneurs conducting Part 107 operations and a few large, professional organizations that have mature sUAS programs.

Remote Pilot Forecast

An important final metric in commercial small drones is the trend in remote pilot (RP) certifications. RPs[59] are used primarily to facilitate commercial and public use small drone flights, as discussed in the preceding section. As of December 2022, a total of 309,713 RP certifications had been issued, an increase of almost 56,000 from the same time last year (2021) and slightly higher than the year before (2020).

Part 107 certifications require completing a multi-step process, beginning with obtaining an FAA tracking number via the creation of an Integrated Airman Certification and Rating Application (IACRA) profile prior to registering for a knowledge test. Following this initial step, scheduling and passing the initial aeronautical knowledge test at a Knowledge Testing Center is required. Provided that one has passed this test, the applicant is required to fill out FAA Form 8710-13 in IACRA. A confirmation email is sent when an applicant has completed the necessary Transportation Security Administration (TSA) security background check. This email contains instructions for printing a copy of the temporary remote pilot certificate from IACRA. A permanent remote pilot certificate is sent via mail once all other FAA-internal processing is complete. An RP certificate is valid for two years, and certificate holders must pass a recurrent knowledge test every two years at a Knowledge Testing Center. It is required that RPs carry their certificate whenever flying a small drone.

Certifications for part 61 operators, on the other hand, require an applicant to hold a pilot certificate issued under 14 CFR part 61, and to have completed a flight review within the previous 24 months. Since part 61 operators already have IACRA profiles established, they are required to complete, like Part 107 operators, FAA Form 8710-13 in IACRA. Upon completion of this form, submission of proof of current flight review, and submission of proof of online course completion, part 61 operators are required to meet with FAA representatives at the FAA Flight Standards District Office (FSDO), or with an FAA-designated pilot examiner (DPE), or an airman certification representative (ACR) or an FAA-certificated flight instructor (CFI), who issues the RP certificate to the part 61 operator. Like their Part 107 counterparts, certificates for part 61 operators are valid for 2 years and require renewal.[60]

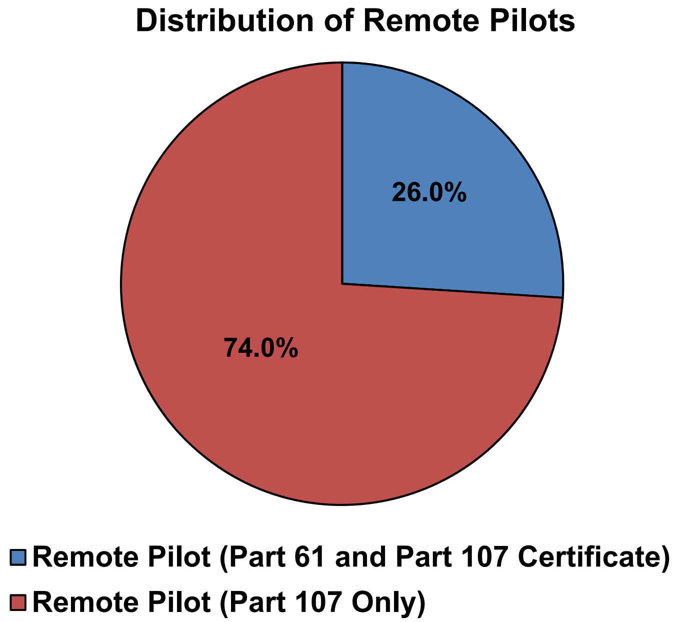
Following the process above, the FAA classifies RPs into two categories:

- those who do not hold any pilot certificate other than the Part 107, or Remote Pilot Only; and
- those who hold a part 61 certificate and a Part 107 certificate, or Part 61 and Remote Pilot.

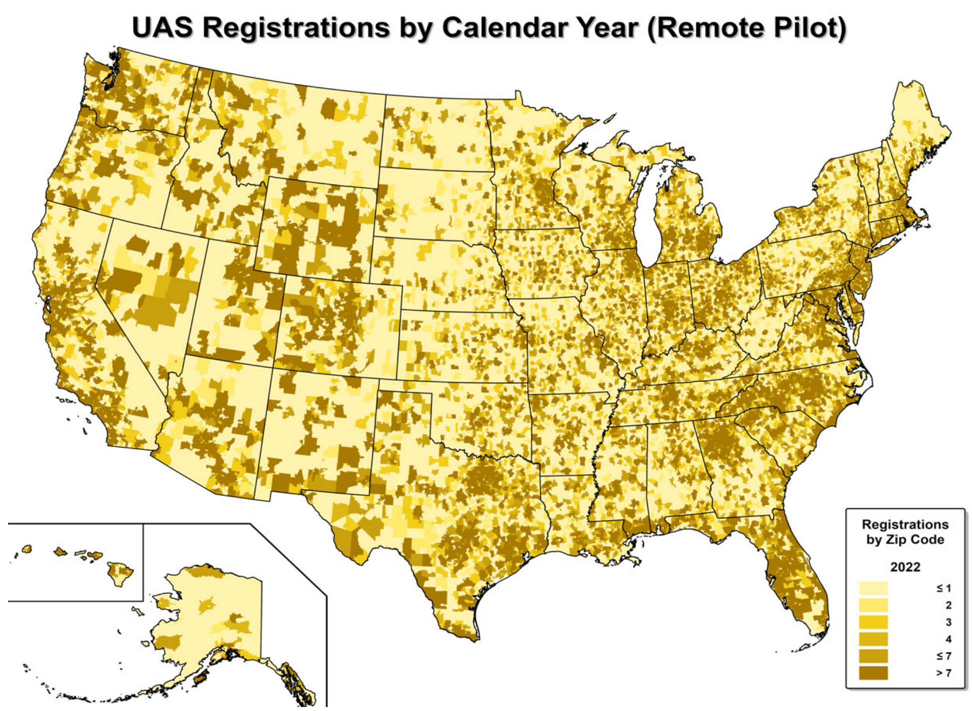
The chart below provides a distribution of these two types of RPs who presently have certificates.

[59] In our accounting of RPs, we take pilots who passed the initial knowledge test (or Part 107), plus current traditional pilots who took online training in lieu of the knowledge test (or part 61).

[60] See https://bit.ly/2AUacmT for more details.

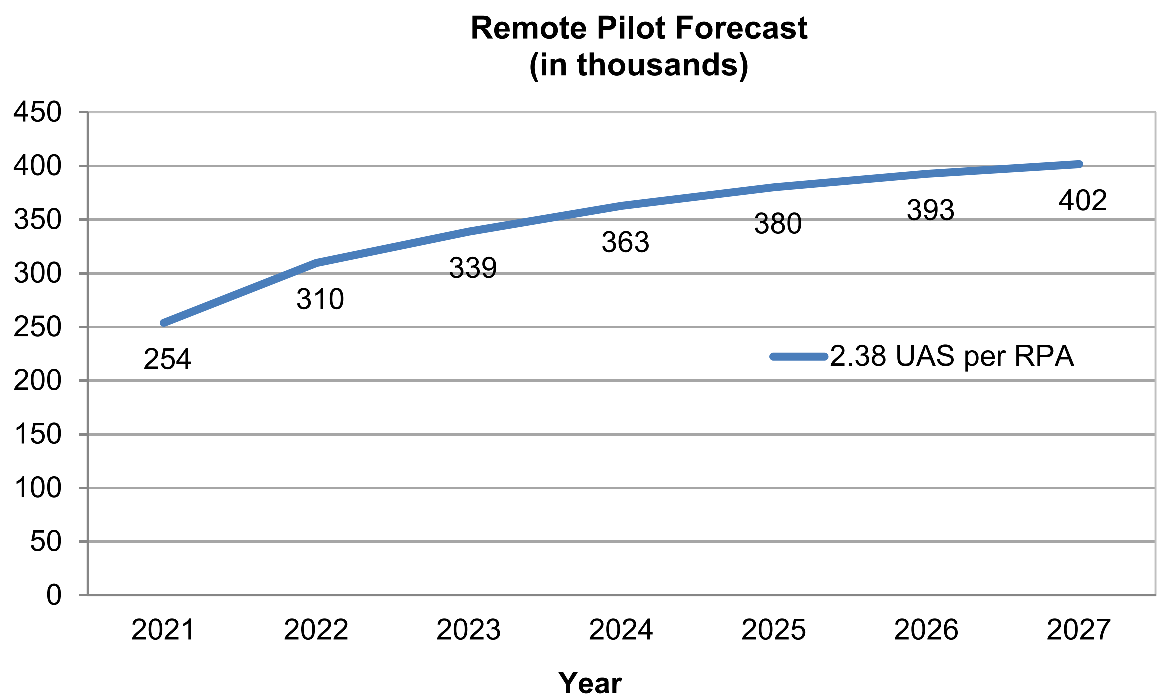


Around 74% of the RPs are Part 107 RPs only. Over 90% of those who took the exam passed and obtained RP certification. A cumulative density distribution of remote pilots by zip codes in 2021 is provided in the map below.



The RP forecasts presented below are based on three primary data sources: (a) trends in total RPs; (b) renewal trends; and (c) trends in commercial small drone registration, or Part 107 and forecasts of fleet. In this context, it is important to note that the empirical relationship between trends in RP and commercial/Part 107 small drone registration, particularly new registration, appear to hold despite expiry, cancellations and renewal. Given the trends in registration and our forecast of the commercial small drone fleet (i.e., base forecasts), the FAA assumes that one pilot is likely to handle 2.38 units of commercial small drone aircraft, the same as the previous three years.

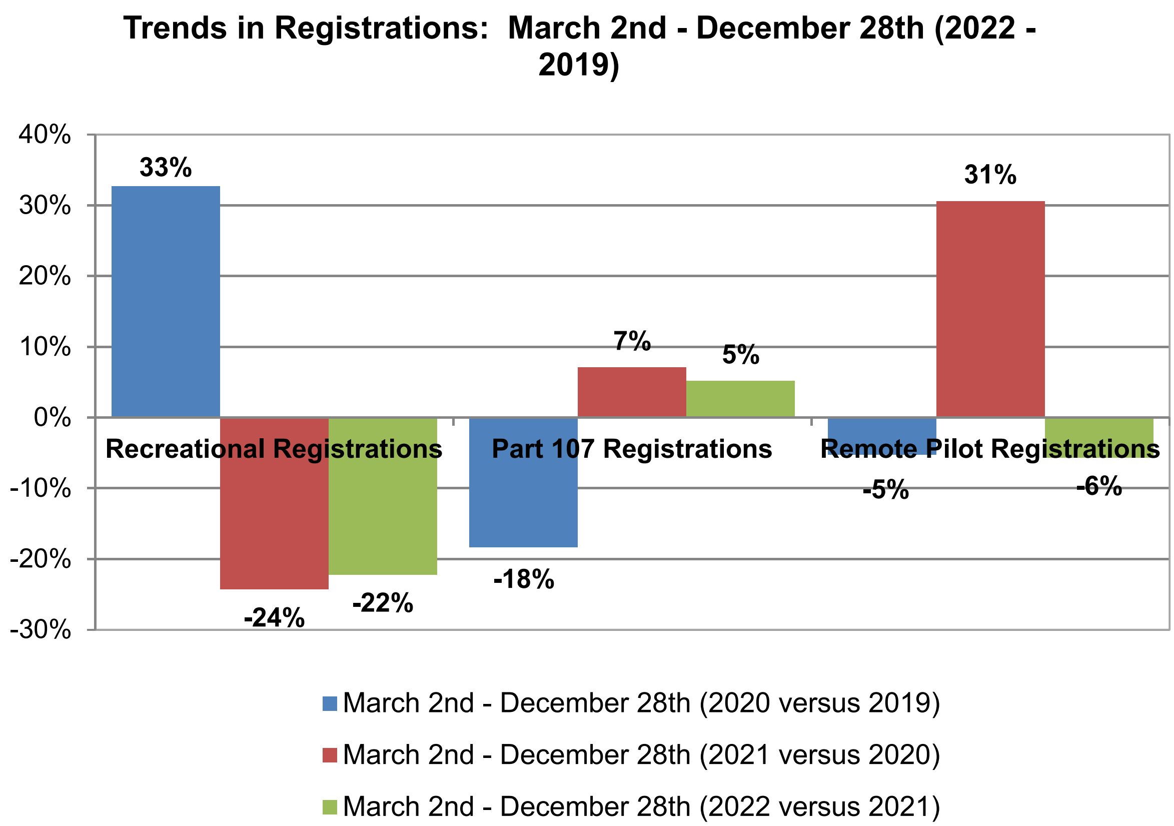
Using these assumptions and combined with the base scenario of the commercial/Part 107 small drone forecast, we project RPs in the graph below. Last year, the FAA projected RPs to be approximately 294,276 by the end of 2022. Actual registrations by the end of 2022 totaled 309,713 (or more than 15,437 from last year's projection) thus actual exceeding last year's projection by 5.25% for 2022.



Given the actual numbers at the end of 2022, RPs are set to experience tremendous growth following the growth trends of the commercial small drone sector. Starting from the base of 309,713 RPs in 2022, commercial activities may require over 401,000 RPs in five years, a 1.3-fold increase that may provide tremendous opportunities for growth in employment—over 92,000 new RP opportunities—associated with commercial and public use activities of small drones. Potential for RPs may enhance even more if larger drones are used in commercial activities and advance air mobility (AAM) becomes a reality in the near future, two topics discussed in the sections below.

COVID-19 and Its Impact on sUAS

The chart below summarizes how COVID-19 may have impacted three areas of registration. During the prolonged and partial economic shut-downs during March – December 2020, and January – December 2021, respectively, and gradual opening during January – December, 2022, it is clear that commercial facets of small drone operations, i.e., Part 107 and RP registrations, were impacted negatively during 2020.



Part 107 registrations dropped by over 18% in 2020 compared to the prior year of 2019, but recovered in 2021 with an increase of 7%. This further continued with 5% increase in the following year, i.e., during 2022. RP registrations dropped by 5% in 2020, followed by a 31% increase in 2021. RP registration declined by 6% during 2022. Interestingly, the registration of recreational users increased by almost 33% during the past year of 2020 in comparison to the year before; however, recreational user registration went down by 24% in the second year of the pandemic and further declined by 22% during the year after of 2022, in comparison with the first year.

While it is quite possible that these drops/increases were led by developments within the Part 107 and recreational communities, we believe that at least some of the observed drops/increases were caused primarily by COVID-19. As the economy slowed down considerably, the use of commercial small drones (and, correspondingly, the use of RPs), may have decreased in the first year, followed by economic adjustments in the following year that allowed for increased commercial use. On the other hand, the economic slowdown may have afforded more time to people working from home to experiment with recreational use of small drones; this may have caused higher recreational registration in the first year of the pandemic in comparison to the prior year. The situation seems to have reversed during 2021-2022, where recreational registrations dropped by 24% and 22% respectively, while Part 107 and RP registrations bounced back by 7% and 31%, respectively, in comparison to the prior year. However, while Part 107 registration continued to climb, RP registration reversed the trend in 2022. The changing nature of registrations, and subsequently forecasts, offers challenges and opportunities for integration of small drones into the NA

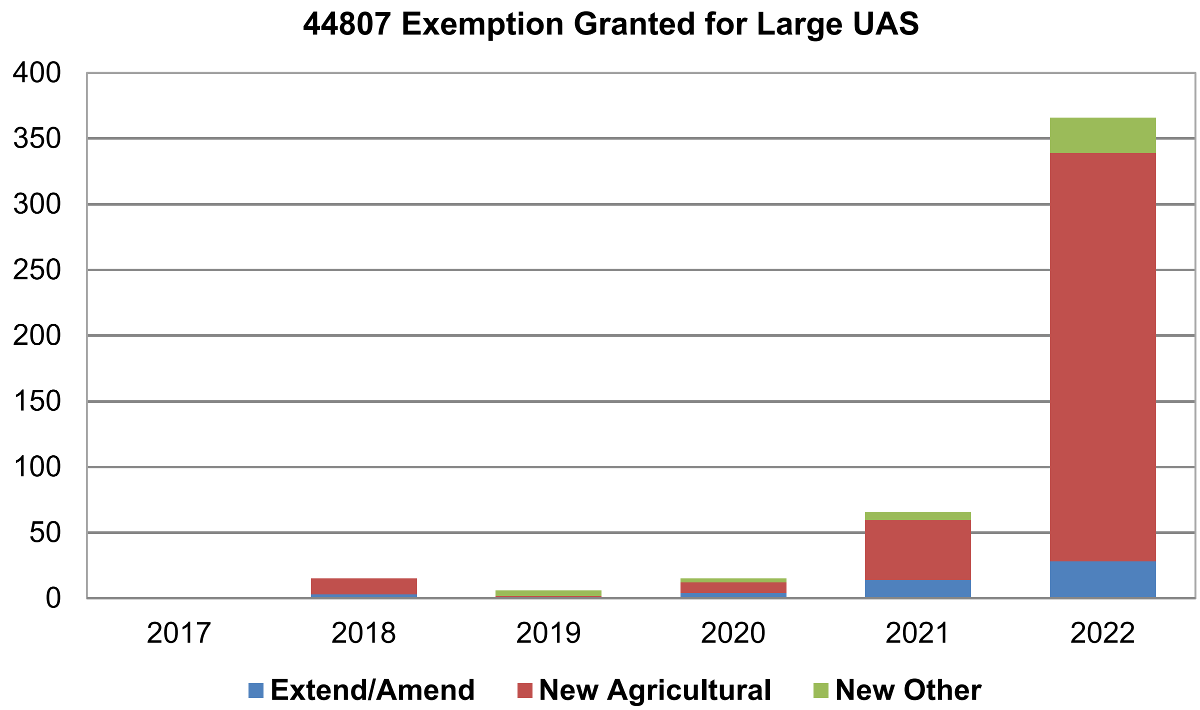
Large UAS

Part 107 limits the gross takeoff weight of uncrewed aircraft (or sUAS) to below 55lbs. Thus, uncrewed aircraft with gross takeoff weights above 55lbs must operate under separate rules and are considered a sepa-rate category of UAS, which are referred to as simply large UAS (lUAS). Since these lUAS are not type certified and do not fall un-der the Part 107 operating rules, operation of these aircraft requires a section 49 U.S.C § 44807 exemption or a public aircraft operator (POA) certification.[61] In addition, the FAA re-quires lUAS operating under a 44807 exemption or POA to receive a tail number by registering the uncrewed aircraft in the public aircraft registry.[62] As such, the lUAS fleet and operations are not contained in or correlated the sUAS discussed in previous sections.

The FAA has been granting 44807 exemption since their introduction in the FAA Reauthorization Act of 2018. Both applications for a 44807 exemption by individuals and organizations and the decisions by the FAA are publicly available.[63] Since 44807 exemptions are required to operate a lUAS for commercial purposes, these exemptions are a leading indicator of both the purchases, which increase the fleet, and the operations, which increases the observed flights, of non-military, commercial lUAS. However, the 44807 exemption is slated to sunset in 2023, unless extended in the 2023 FAA Reauthorization bill. Given exemptions are only valid for two years from the date they are granted, we could see all operations of lUAS disappear by 2025 without additional legislation.

[61] See https://bit.ly/3KxiuVX for more details.
[62] See https://bit.ly/3ZIcCxJ.
[63] All 44807-exemption applications and decisions are available at regulations.gov in the “Other” category.

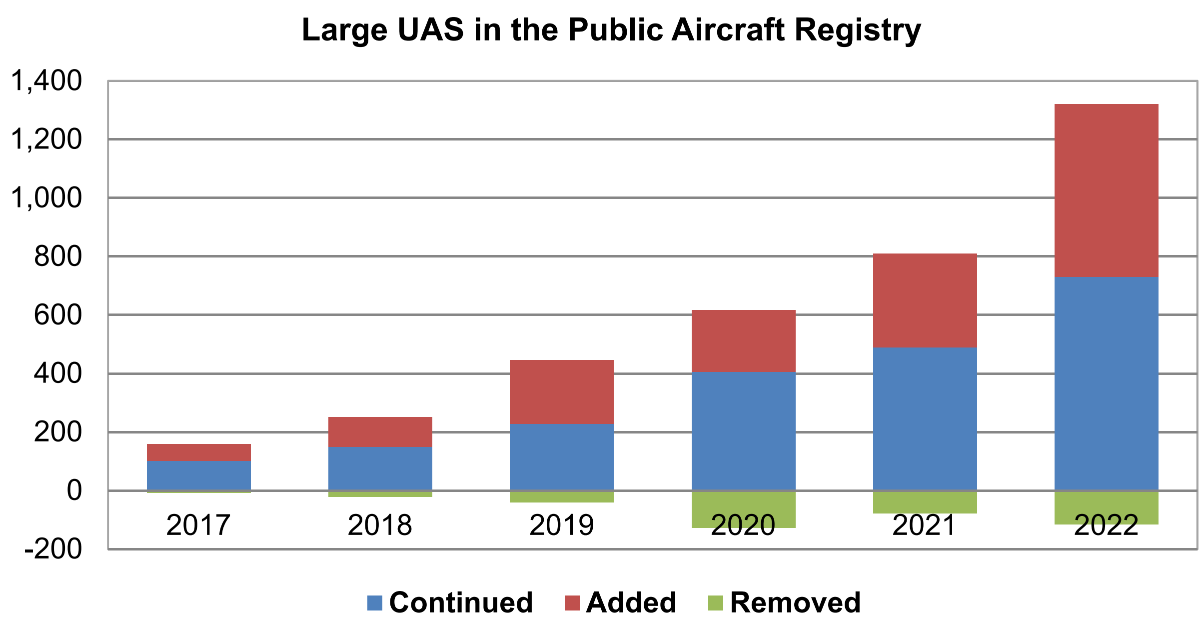
The FAA has granted 366 exemption in 2022, an astounding 450% increase from 2021. Just under 8% of exemptions (28) were amendments or extensions of existing exemption. Eighty-five percent of exemptions (311) were granted for agricultural-spraying applications, up by almost 600% from 2021. The remaining roughly 7% (27) were for other applications, including aerial photography, parcel delivery, and infrastructure inspection, in order of quantity granted. Of the granted exemptions, 85% were filed by only 5 firms representing end-use operators.



The rapid increase in exemptions granted suggests that the safety cases for specific operation have been sufficiently demonstrated to regulators such that the granting exemptions for these narrow operations is now routine. In addition, the small number of firms representing operators suggests specialization in communicating these narrow uses to regulators. Moreover, the growth in 44807 exemptions indicates that we should expect larger fleets of IUAS in the future as operators with exemptions scale their operations to meet economic opportunities. However, since the bulk of new exemptions granted are for agricultural use, the majority of new IUAS will operate close to the ground in agricultural regions and thus, are unlikely to be observed operating in the NAS, particularly in the controlled airspace environment.

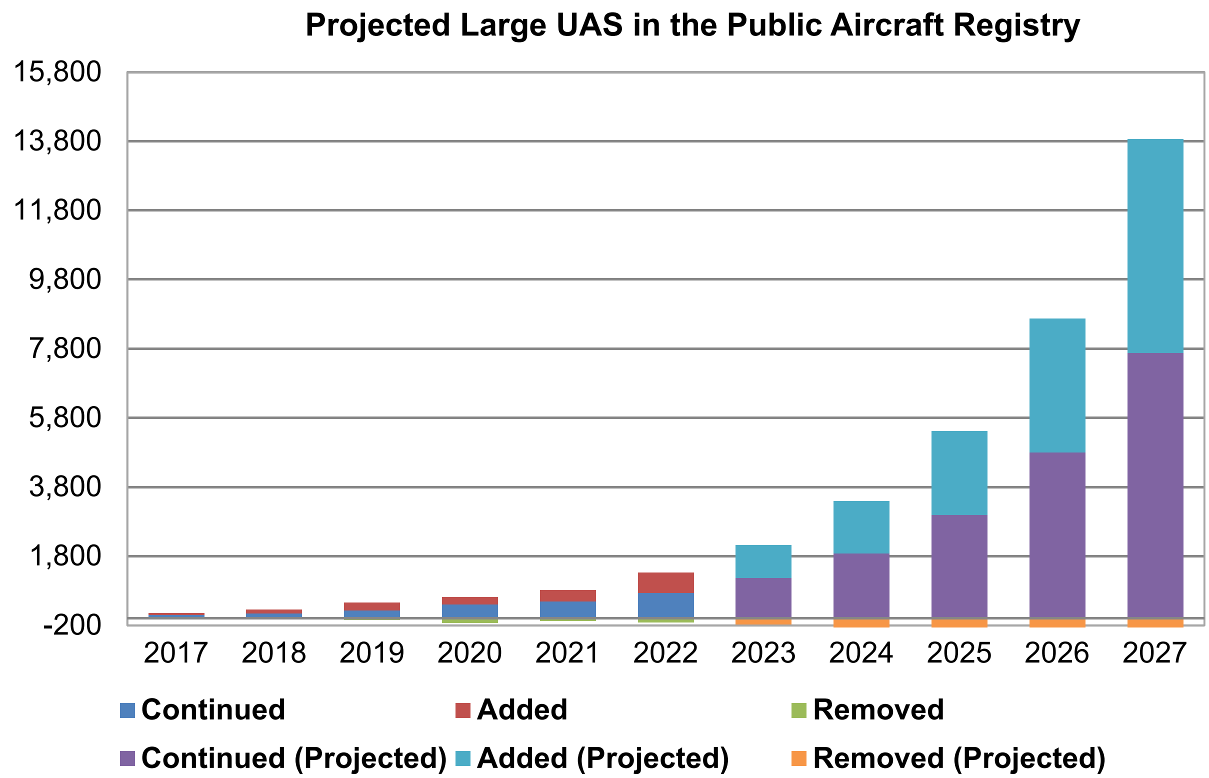
Since IUAS are required to register with the Public Aircraft Registry (PAR), we can use the PAR to estimate the IUAS active fleet. Using the Aircraft Reference file from the PAR, we identify the IUAS in the Aircraft Registration Master file and the Deregistered Aircraft file from which we calculate the active fleet of lUAS.[64] In 2022, 590 new lUAS aircraft were added to the PAR, an 84% increase from 2021. Sixteen percent of aircraft registered at the end of 2021 (115) were delisted in 2022, producing an active fleet of 1,206 lUAS by the end of 2022.

With robust demand for lUAS operation indicated by 44807 exemptions, we expect the growth of new lUAS over the next 5 years to keep pace with the growth observed in 2022. As such, we expect 6,189 new lUAS will be added to the PAR in 2027, with a total active lUAS fleet of 12,651 aircraft by the end of 2027. This forecast assumes that 44807 exemption, or an equivalently permissive rule, remains in place until 2027. However, the uncertainty regarding the availability of the 44807 exemptions presents a headwind for the expansion of the lUAS sector. Additionally, with interest rates elevated for 2023 and possibly remaining elevated into the future, the resulting increase in the cost of capital is also likely to reduce the growth of the active fleet as less capital is available for the development of associated technologies and elevated financing cost reduce aircraft purchases.[65]



[64] The Public Aircraft Registry data for 2022 is available at https://bit.ly/433iqET. Uncrewed aircraft are separated from crewed aircraft using the "NO-SEATS" field in the Aircraft Reference file. The "AC-WEIGHT" field is used to remove all small uncrewed aircraft, and the "TYPE-ACFT" field is used to remove all lighter-than-air aircraft, including blimps and balloons. The remaining codes – held within the "CODE" field – are matched with the "MFR MDL CODE" in the Aircraft Registration Master file and the Deregistered Aircraft file, and adjusted based on the "STATUS CODE" field. The remaining aircraft are sorted for the year the registered using the "CERT ISSUE DATE" or "LAST ACTION DATE". The count of new registration (2022), older registrations (2021 and older), and delisted registrations (2022) are used to construct the active lUAS fleet.

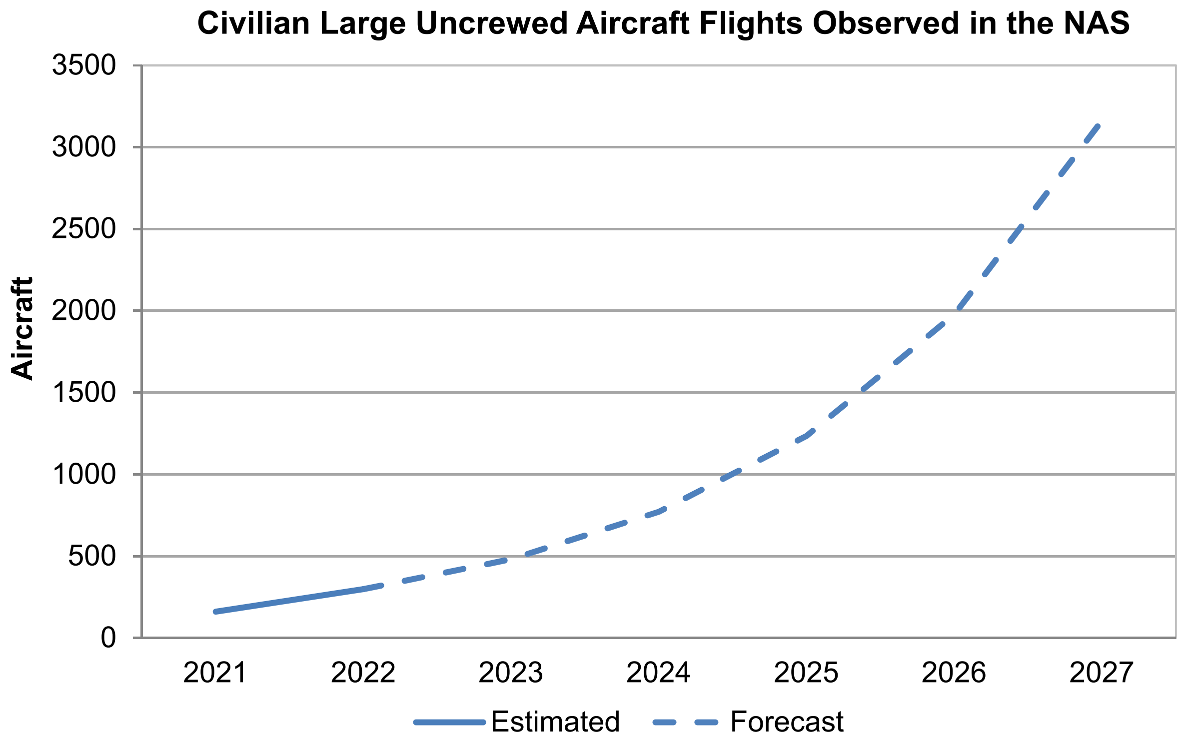
[65] The Federal Funds Effective Rate has risen from 0.8% at the beginning of 2022 to 4.57% at the beginning of 2023 and Moody's Aaa bond yields have increased from 2.93% at the beginning of 2022 to 4.40% at the beginning of 2023. Both suggest higher costs of borrowing for capital purchases.



Although the active fleet can be observed from the PAR, the operations of IUAS are more difficult to observe. As such, the FAA uses MITRE's Threaded Track data[66] to estimate the number of non-military, IUAS flights. Since the Threaded Tracked data only captures activity in controlled airspace, flights by IUAS operator close to the ground, such as agricultural drones, are not included in these flights.[67] According to the 2022 Threaded Track data, 299 flights were taken by IUAS for non-military or civilian purposes, which is an 86% increase from the previous year (161 flights in 2021).

[66] See https://bit.ly/3GhsMao for more details.

[67] In previous years' Aerospace Forecast, we included both military and civilian flights in our estimates of large UAS activity in the NAS. However, with the inclusion of the Public Aircraft Registry data as an estimate for the active fleet of UAS with weights above 55lbs, military large UAS have been removed from the active fleet. To provide consistency across estimates, we have eliminated all Threaded Track originating or terminating at military installations or tail numbers that have ever originated or terminated at a military installation. As such, the remainder have been assigned as non-military or civilian with a high degree of confidence.



The increase in observed flights seems to mirror the increase in the active fleet, both around 85%. However, the number of IUAS flights observed is only 0.25 flights per IUAS registered in the PAR, which is far too low to be economically rational. This suggests that many flights are not being observed through the Threaded Track data due to the bulk of flights being conducted in proximity to the ground. As the data on 44807 exemption granted suggest, most of the IUAS operations are most likely agricultural-spraying operations. Agricultural-spraying IUAS operate close to the ground to avoid pesticide drift.[68] As such, IUAS agricultural-spraying flights which the 44807 grants data suggests in the bulk of IUAS operations, are not observable, and thus, the observable flights are likely only a fraction of the actual IUAS flights.

UAS Imports: Preliminary Analysis of Data

On January 27th 2022, the White House issued a proclamation to update the Harmonized Trade Schedule of the United States (HTSUS) to match recommendations by the World Customs Organization.[69] As part of the update, UAS received their own categories, separating UAS from crewed aircraft or toys.

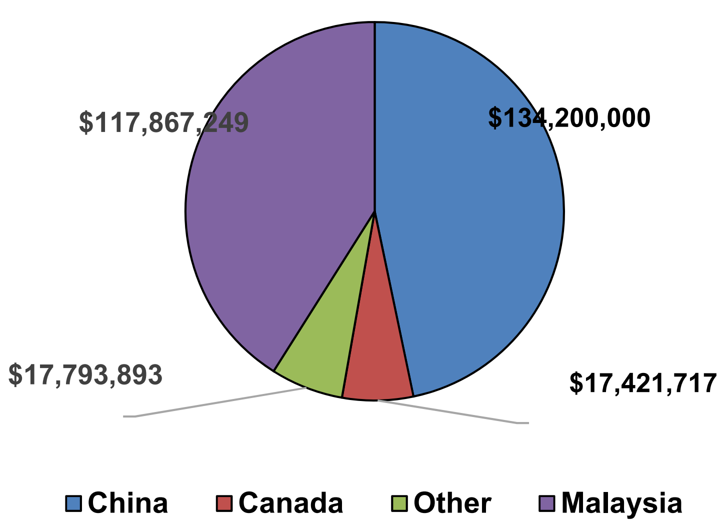
[68] Pesticide drift is when the movement of the aircraft or wind while spraying moves the pesticide away from its intended target. Pesticide drift is regulated by the EPA. For more information, see https://bit.ly/41iQf3d.

[69] See the U.S. President's proclamation: https://bit.ly/3K9YY0C; World Customs Organization's amendments: https://bit.ly/42ZzqvL.

The new schedule splits UAS into several categories based on weight and a special category for UAS capable of passenger services (See table below).[70] The new HTSUS has given the FAA addition information regarding the number of UAS purchased in the United States. This is particularly useful given that the vast majority of sUAS operator within the United States are import.

Code	Type	Weight
8806	Rc Unmanned Aircraft	
8806.10	Rc Unmanned Aircraft Carriage of Passengers	Unspecified
8806.21	Rc Unmanned Aircraft	Not Over 250 g
8806.22	Rc Unmanned Aircraft	250 g - 7 kg
8806.23	Rc Unmanned Aircraft	7 kg - 25 kg
8806.24	Rc Unmanned Aircraft	25 kg - 150 kg
8806.29	Rc Unmanned Aircraft	> 150 kg

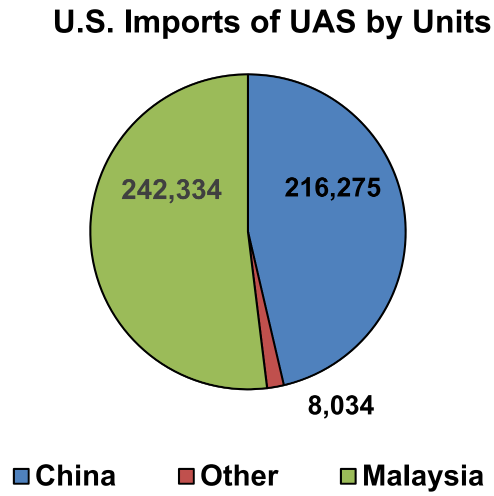
U.S. Imports of UAS by Value

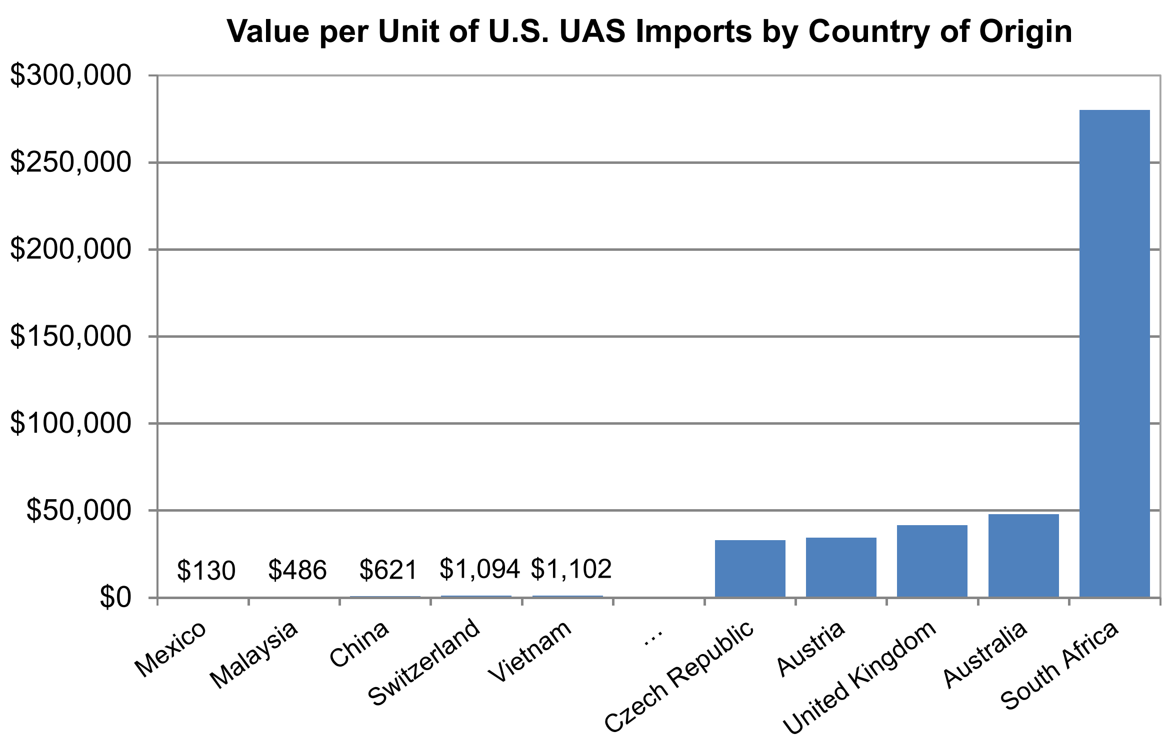


In 2022, the United States imported more than 466,000 UAS worth $287 million. The vast majority of UAS imports, both in terms of value and units, are from either China or

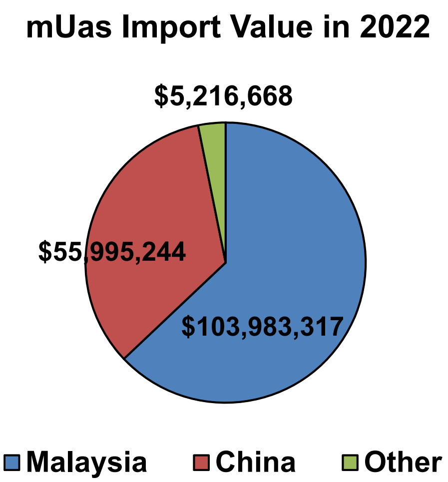
[70] The categories also included "Not Elsewhere Specified or Included (NESOI)" and "duplicate category" for each of the sub-category codes.

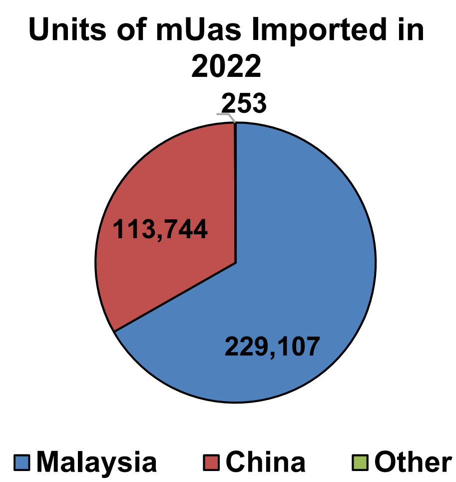
Malaysia with Canada being a notable exporter of UAS in terms of values. On average, both China and Malaysia are exporting low value UAS occupying bottom 5 in terms of value per unit imported into the United States, along with Mexico, Switzerland, and Vietnam. Conversely, South Africa, Australia, the UK, Austria, and the Czech Republic have the highest value per unit.



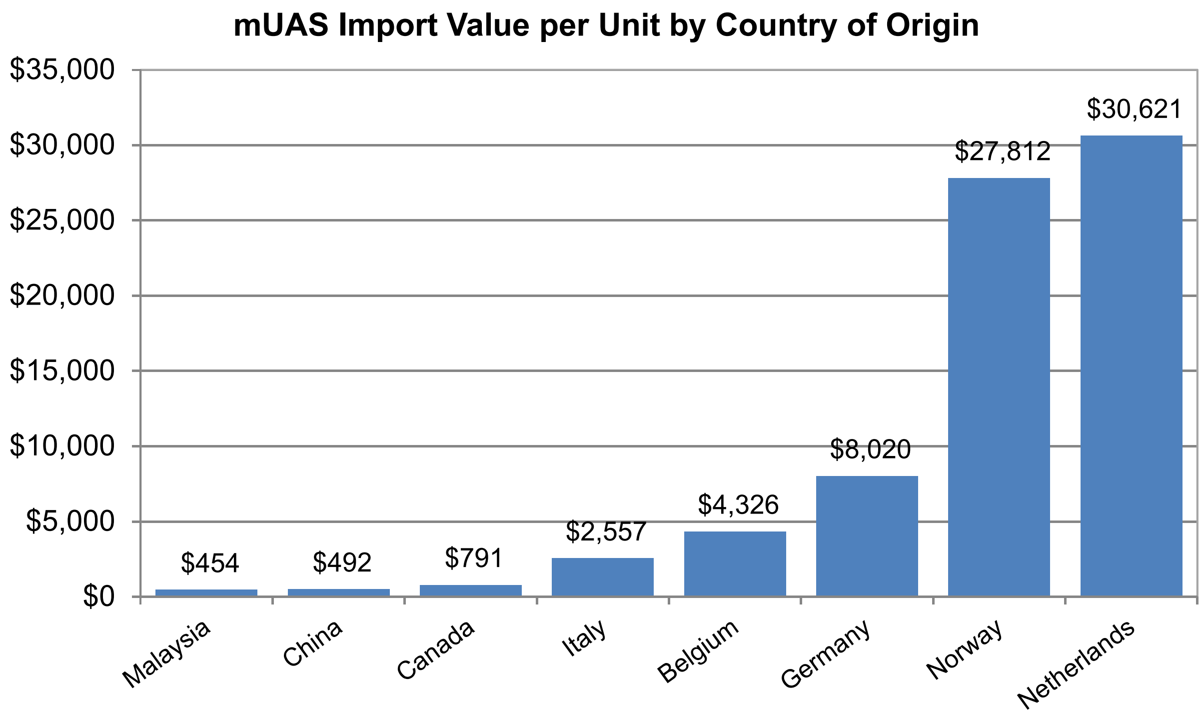


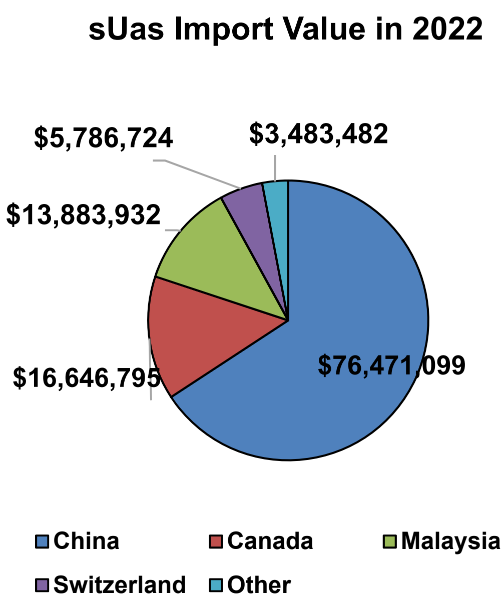
Using the codes for UAS, the imported UAS can be segmented based on weight. Part 107 and Section 44809 do not require operator with UAS weighing less than 0.55lbs (or 250g) to register under Part 107 or Section 44809 and both Part 107 and section 44809 forbid the operation of UAS greater than 55lbs (or 25kg). As such, we binned the imports into three categories: micro UAS (mUAS < 0.55lbs), small UAS (0.55lbs < sUAS < 55lbs), and large UAS (lUAS > 55lbs). Thus, mUAS includes 8806.21, sUAS includes 8806.22 and 8806.23, and lUAS includes 8806.24 and 8806.29 [see sub-codes in table above]. The remaining category of UAS capable of passenger services (8809.10) did not have any reported imports in 2022 and is ignored.

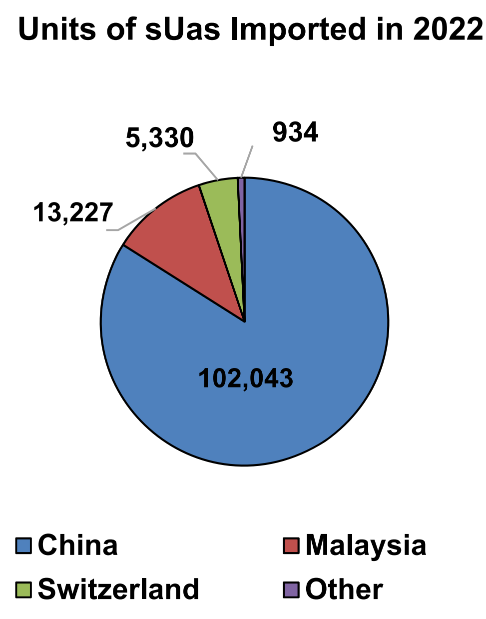


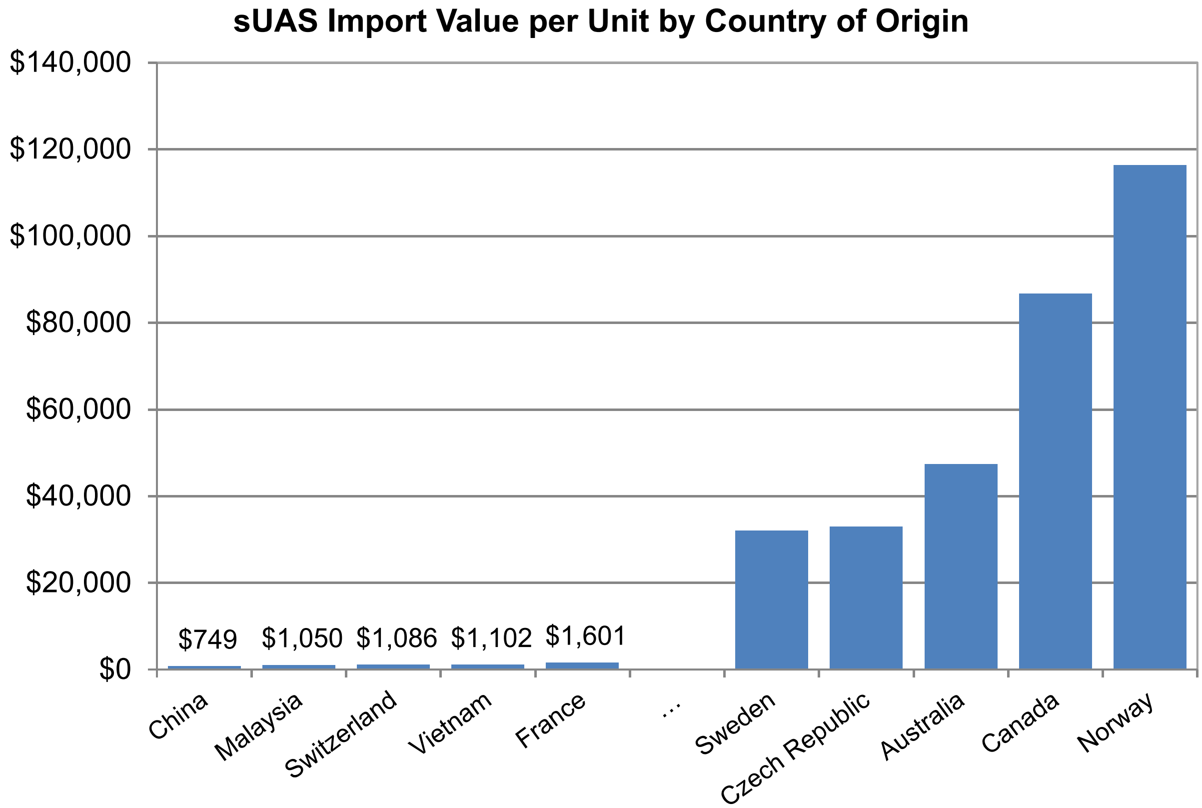


A total of 343,104 mUAS were imported into the United States in 2022 with a value of over $165 million. China and Malaysia dominated this segment of the UAS market, exporting 113,744 and 229,107 units worth $56 million and $104 million, respectively. Between the two countries, their exports to the United States made up 99.9% of the mUAS imported. However, the average value per unit of the imports from China and Malaysia are less than $500, the least expensive of this category of UAS. The Netherlands and Norway had the most expensive units exported to the United States with an average value of $30,621 and $27,812 per unit, respectively, although few units were imported.


mUAS Import Value per Unit by Country of Origin
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
$454
$492
$791
$2,557
$4,326
$8,020
$27,812
$30,621
Malaysia
China
Canada
Italy
Belgium
Germany
Norway
Netherlands

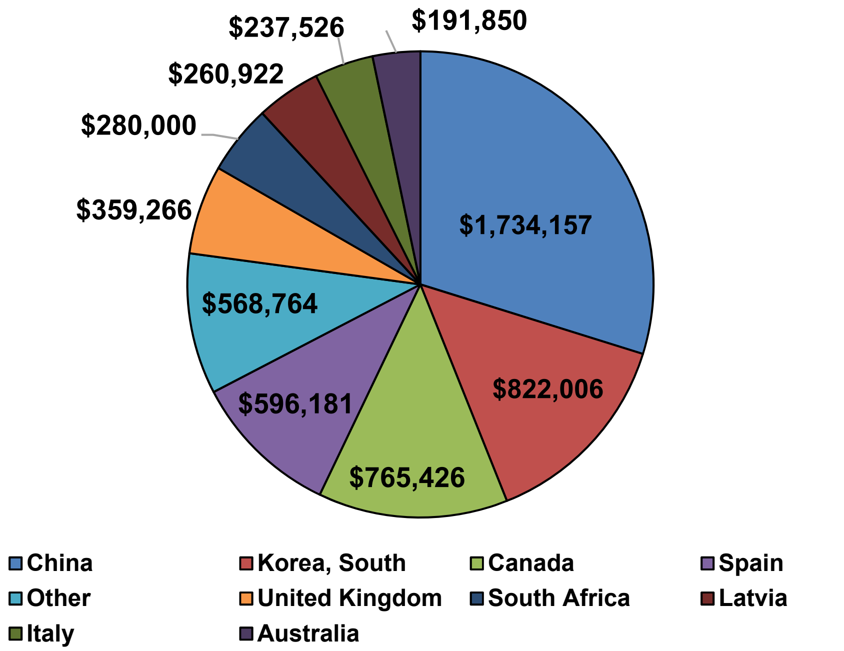

sUas Import Value in 2022
$5,786,724
$3,483,482
$13,883,932
$16,646,795
$76,471,099
China
Canada
Malaysia
Switzerland
Other


Units of sUas Imported in 2022
5,330
934
13,227
102,043
China
Malaysia
Switzerland
Other

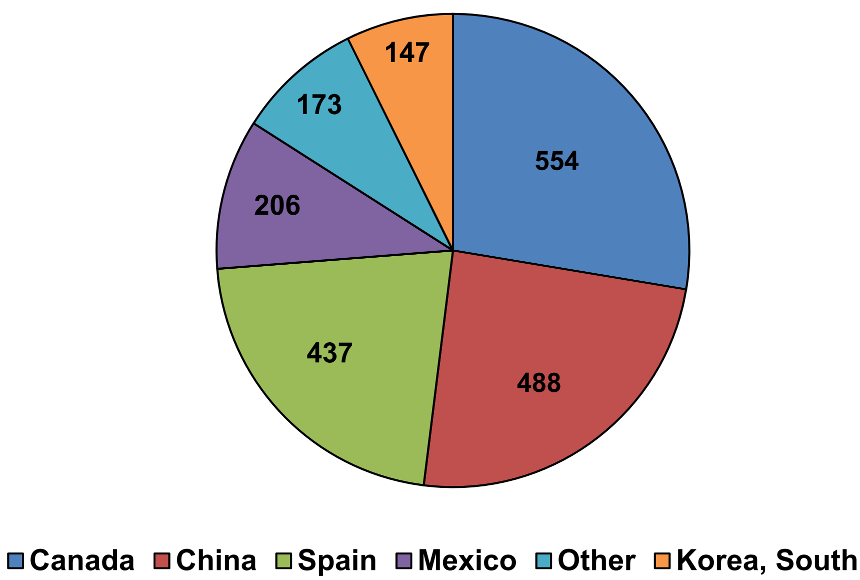


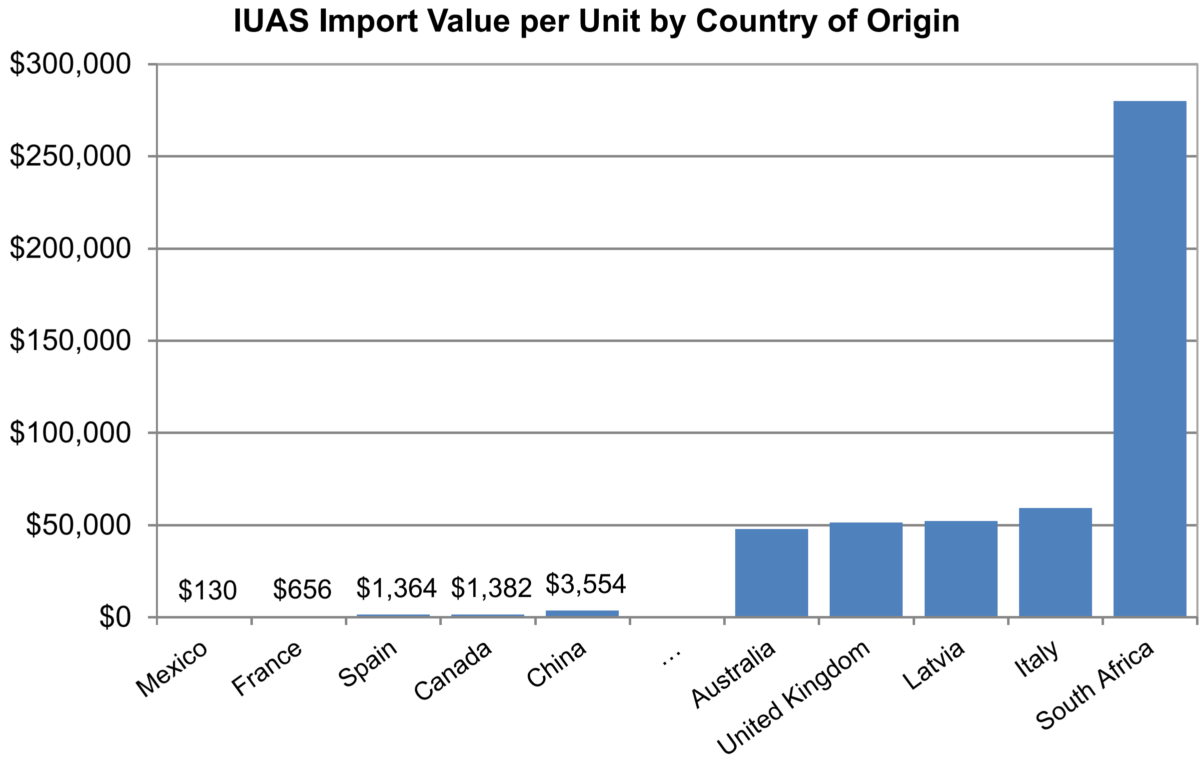
The United States imported 121,534 units of sUAS in 2022 valued at $116 million. Imports from China dominate this segment of the UAS market with 102,043 units imported, 84 percent of all sUAS imported into the United States. By value, the sUAS imports from China exceeded $76 million, 65.8% of sUAS imports by value. sUAS imports from Canada, Malaysia, and Switzerland were valued at $16.6 million, $13.9 million, and $5.8 million (14.2%, 11.9%, and 5%) of sUAS imports by value, respectively. Although China, Malaysia and Switzerland exported a considerable number of sUAS to the United States, the average value per unit were the smallest of all exporting countries at $749, $1,050, and $1,086 per unit, respectively. Canada, on the other hand, exported only 192 unit to the United State, but the sUAS had an average value of over $86,000 per unit, the second highest value per unit. However, Norway had the highest value per unit imported into the United States at $116,000 per unit on average.

IUas Import Value in 2022



Units of IUas Imported in 2022





IUAS was the most diverse of the imports. In 2022, the United States imported 2,005 units of IUAS valued at $5.8 million. Once again, China was the dominant exporter to the United States but only in terms of value. The United States imported 488 units from China valued at $1.7 million, 29.8% and 24.3% of IUAS imports in terms of units and value, respectively. Canada was the largest exporter to the United States in terms of units with 554 units with a value of $765,000. Mexico, France, Spain, Canada, and China had the lowest value per unit imported; with imports from Mexico at only $130 per unit. Conversely, Australia, the U.K., Latvia, Italy, and South Africa had the highest value per unit with South Africa boasting $280,000 per unit.

Although China plays a major role in all three segments of the UAS markets, it only has significant market dominance in the sUAS market. Malaysia is also a major exporter to the United States, where it is the largest exporter of mUAS both in terms of units and value. Canada seems to be exporting UAS further up the value chain than either Malaysia or China providing higher valued sUAS and IUAS. Switzerland plays a small but significant role in the sUAS market, providing UAS at a similar price point to Chinese exports. Overall, China is a dominant exporter in UAS markets in the United State, but many other countries provide an alternative to Chinese exports at similar price points.

Given the extent to which the U.S. market for both mUAS and sUAS is dominated by imports, the import data are a fair estimate of the number of UAS added to the U.S. fleets, especially for sUAS sectors including both recreational and Part 107. As such, new registration could be limited to the number of sUAS imports observed. However, given that 2022 was the first year that import data for UAS were tracked, we only know the current state of the imports, and we cannot estimate the possible growth of imports over time. In addition, the new schedule did not start until January 27th of 2022, and it is possible that companies exported as much inventory as possible in late 2021 and early January 2022 to avoid higher duties. As such, the number of sUAS imported in 2022 could be far less than an average year. Several additional years of import data is required to make full use of this data to support the sUAS forecast. The FAA plans to track these data going forward.

Advance Air Mobility

In September 2017, NASA launched a market study for a segment crossing over some functions of drone activities discussed above. This segment of initially piloted and autonomous vehicles in the future, broadly called AAM, is defined as "a safe and efficient system for air passenger and cargo transportation, inclusive of small parcel delivery and other urban drone services, which supports a mix of onboard/ground-piloted and increasingly- autonomous operations."[71] [72] Urban air mobility (or UAM), within the broad AAM category, is thus envisioned as a transportation system that is likely to use piloted/automated aircraft to transport passengers and cargo at lower altitude within urban and suburban areas.

Building on the UAM concept by incorporating use cases not specific to operations in an urban environment, the FAA defines the scope of AAM broadly as follows:[73]

- Commercial Inter-city (Longer Range/Thin Haul);
- Cargo Delivery;
- Public Services; and
- Private / Recreational Vehicles.

AAM technology presents considerable opportunities for economic growth over the coming decades. Markets for AAM services, such as package delivery by drone or larger autonomous or remotely piloted cargo delivery, airport shuttling (or services along the fixed routes between urban locations to airports and vice versa), or traditionally-piloted, remotely-piloted, or autonomous passenger shuttles or air taxis (i.e., on-demand point-to-point services) have significant potential both in the United States and globally.[74] For example, package or larger cargo delivery is the AAM service that is most likely to experience economic growth in the next decade. Drone delivery services have been presently operating in Arkansas, Florida, Arizona, and Texas, with Virginia and Utah soon to follow. As of December 2022, drones delivered more than 10,000 items up to ten pounds in as little as 30 minutes for a delivery fee of

[71] The community is in the process of establishing nomenclature. Only recently, the community-at-large has moved on to coining earlier-used "urban air mobility" (UAM) as "advanced air mobility" (AAM) to broaden its operational scope, technical characteristics, economic opportunities, and regulatory framework. Under this broad characterization, UAM is considered a subset of AAM.
[72] See https://go.nasa.gov/40Y4hXM.
[73] See https://bit.ly/3U7W2pA.
[74] There appears to be a broad consensus where eVTOLs are expected to be piloted initially (likely during 2025-2030) followed by transition to remotely piloted with increasingly autonomous operations (likely during 2035 and beyond) based on the current state in autonomy research and development, and present status of certification procedures [see Urban Air Mobility: An Airport Perspective (2023), ACRP Research Report #243; available at https://bit.ly/40HQhBu.

$3.99.[75] The growth trajectory is anticipated to accelerate once FAA permits BVLOS operations. By 2030, package delivery is likely to be profitable at a price point of $4.20 per delivery, with a fleet of 40,000 vehicles completing 500 million deliveries per year.[76]

Passenger services, on the other hand, promise larger markets for AAM services, but safety challenges, infrastructure, public acceptance, and evolving technology leading to market uncertainties may determine both the entry into services (EIS) and the pace of AAM's penetration into this segment of the market. Nevertheless, flight testing continues to elucidate the performance dynamics of electric vertical take-off and landing (eVTOL). For example, Joby Aviation announced in July 2021 that it has completed a test flight which surpassed 150 miles on a single charge with its eVTOL aircraft. Recently, AutoFlight broke that record and reported that its test flight completed 155 miles on a single charge on February 23 of this year.[77] Collectively, the industry recorded over 6,000 cumulative flight hours of aircraft testing over the past few years, many in 2022.[78]

The increasing number of flight tests and data collection are paving the way for type certification (TC) of eVTOL aircraft. Since becoming the first eVTOL company to sign a G-1 certification basis with the FAA in 2020, Joby has continued to demonstrate progress in obtaining TC for its eVTOL aircraft. In February 2022, Joby announced it completed the first series of conformity testing observed by an on-site FAA designated engineering representative (DER) to evaluate the material strength of its eVTOL components.[79] In March 2022, Joby announced the completion and subsequent approval of its first systems and compliance review by the FAA. The systems review assessed Joby's plans and process for the development of flight controls, propulsion controls, battery management, other systems and equipment, while the compliance review evaluated Joby's approach to the development and verification of aerospace-grade software and airborne electronic hardware.[80] Later in March 2022, Joby submitted its first area-specific certification plan to the FAA, becoming the first eVTOL company to do so. In the plan, Joby lays out "the combination of design reports, analysis and testing that it will employ to demonstrate compliance with rigorous FAA safety standards".[81] In May 2022, Joby received its Part 135 air carrier certificate from the FAA. This will allow Joby to operate commercial air taxi operations using traditional aircraft to test routes and services while obtaining a TC and a production certificate (PC) for its eVTOL. In 2022, Joby also applied for its eVTOL aircraft to be certified for use in the United Kingdom and in Japan.

There is also eVTOL TC progress globally. In February 2022, Eve Urban Air Mobility, which plans to operate eVTOL flights in Brazil and in Latin America, formalized the process for obtaining TC from the National Civil Aviation Agency – Brazil for its eVTOL aircraft (with deliveries expected to start in 2026).[82] German air taxi manufacturer, Volocopter, obtained a production organization

[75] See https://bit.ly/3Kv8QTZ for a discussion.
[76] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. [See https://go.nasa.gov/2C5Ten9].
[77] See https://bit.ly/40VdeAW.
[78] See https://mck.co/3KyvHhx.
[79] https://bit.ly/4117bek.
[80] https://bit.ly/3KzFTq6.
[81] https://bit.ly/3ZFA1Qi.
[82] Eve Urban Air Mobility, an Embraer company, went public through a merger with a special purpose acquisition company (SPAC) in May 2022,

approval (POA) from the European Union Aviation Safety Agency (EASA)[83] and achieved application for concurrent TC for VoloCity by both EASA and Japan Civil Aviation Board (JCAB). VoloCity air taxi appears to be on target to achieve certification from EASA in 2024 and plan to fly during the 2025 EXPO Osaka Kansai.[84] The company is pursuing concurrent validation with three non-European civil aviation authorities: JCAB in Japan, FAA, and the Civil Aviation Authority of Singapore (CAAS) in Singapore.[85] In similar vein, Joby Aviation, in collaboration with ST Telecom, signed a partnership on February 6, 2022 to introduce aerial ridesharing services to cities and communities in South Korea.[86] Airbus expects its UAM aircraft to meet EASA certification standards (EASA SC-VTOL Enhanced Category) and receive TC around 2025.[87]

Progress in TC appears to signal imminent entry of eVTOL into services. In order to facilitate the AAM market to grow and prosper in the US, the president signed the Bill S.516 into law on Oct 17, 2022 known as *Advanced Air Mobility Coordination and Leadership Act*.[88] Under this Act, AAM is referred as an air transportation system that moves people and cargo between places using new aircraft designs that are integrated into existing airspace operations as well as operated in local, regional, intraregional, rural, and urban environments. The law directs the US Department of Transportation (USDDOT) to establish an Advanced Air Mobility (AAM) interagency working group by February 14, 2023 (i.e., 120 days from enactment of the Law) to plan and coordinate efforts related to the safety, infrastructure, physical security, cybersecurity, and federal investment necessary to bolster the AAM ecosystem, particularly passenger-carrying aircraft, in the US.

The primary purpose of the working group is to make recommendations focusing on economic opportunities, workforce, security, and infrastructure, areas beyond traditional federal roles in aircraft certification and operations. It is also tasked with reviewing the views of various stakeholders, including aircraft operators and original equipment manufacturers (OEMs), airports, labor groups, state, local, and tribal officials, consumer groups, and first responders. Drawing on these inputs, ultimately, the working group is tasked with developing a national strategy for the integration of advanced air mobility vehicles into the NAS. It is anticipated that corporate work plans within different LOBs of the FAA including AAM CONOPS[89] will complement the national strategy.

With an aim to strengthen these initiatives and need to better understand likely market conditions and demand signals, and correspondingly, the need for resources for planning including workforce, airspace and infrastructure, the FAA had launched several research studies on numerous aspects of AAM. One of the recently completed research is now publicly available.[90]

as predecessors Joby, Archer, Lilium, Vertical Aerospace have done so already; and recently in March, 2023 Jaunt Air Mobility, as a wholly-owned subsidiary of AIRO Group, went public as well.

[83] https://bit.ly/3zwogkt.

[84] Joby and Vertical are also planning to provide services, in addition to Volocopter, during Expo 2025 in Osaka.

[85] See https://bit.ly/3nMUxkR.

[86] See https://bit.ly/3nFfy0x.

[87] https://bit.ly/3KdIwMV.

[88] See https://bit.ly/3KxQwJO for more details.

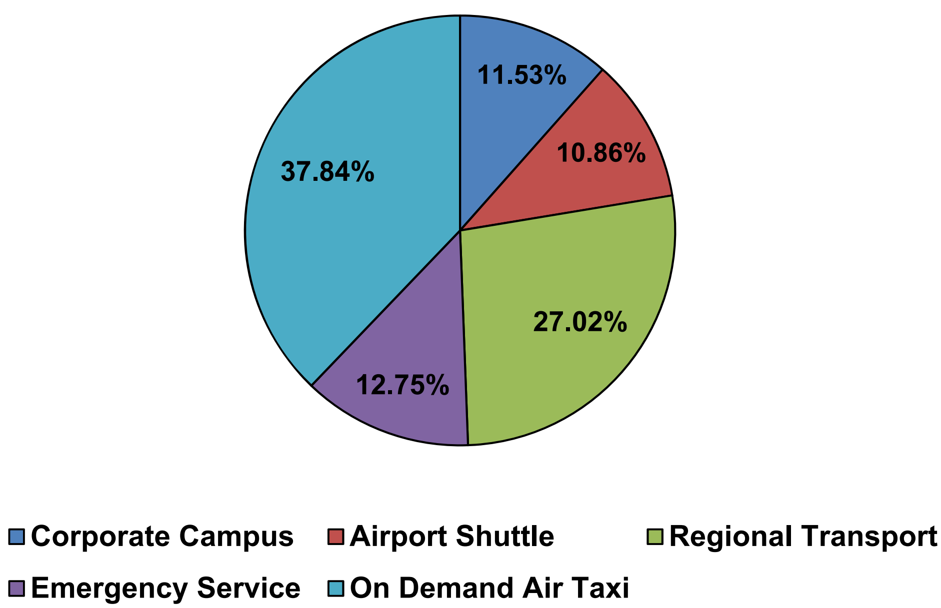
[89] For the version 1.0, see https://go.nasa.gov/3ZJASzr. Version 2.0 of FAA's AAM CONOPS is likely to be published in the spring of 2023.

[90] https://bit.ly/3U60IfX.

The research was divided into three broad work packages: Evaluation of AAM market potential: economic feasibility, potential size and growth, characteristics of population, and ground infrastructure (work package 1 or WP1); WP 2: Airworthiness regulations and its applicability to AAM aircraft certification; and WP 3: Evaluation of AAM integration on the NAS, air traffic control and operations in particular. Drawn on these individual WPs, WP4 provides the final report with recommendations for future research.

The emergence of AAM will likely bring about a variety of new services in five distinct market segments, including airport shuttles, regional air mobility, on demand air taxis, corporate campus shuttles, and emergency services. Some of these services, particularly regional transport, may be served by eVTOLs as well as short take-off and landing (STOL) and conventional take-off and landing (CTOL) vehicles.[91] ASSURE research broadly defines the following categories of services that will likely be served by AAM and their anticipated market share distribution:

Categories Served by AAM



Airport shuttles and similar fixed-route passenger services are the most likely AAM passenger services to gain economic tractions in the coming decade.[92] On demand air taxi is likely soon follow. Optimistic reports project the AAM passenger industry to have 23,000

[91] Some of these vehicles may even be powered by electric propulsion thus making them eSTOL and eCTOL, hybrid (i.e., gas and electric), or even hydrogen-cell powered, when available. For example, BETA announced on March 14, 2023 that it will pursue certification of a conventional fixed-wing electric aircraft (CX300) in addition to developing eVTOL air taxi (Alia-250).

[92] As noted in ACRP Report #243 [see https://bit.ly/3ma8EAg] airport shuttle services connecting airports to city centers are believed by many stakeholders to be an early proving ground for air metro leading to scale. However, other distributions following service prioritization are possible as well; e.g., search and rescue missions

aircraft with 740 million enplanements per year at a price of around $30 per trip by 2030.[93] However, several other studies have reported more conservative estimates, arguing that market penetration is likely to be limited to a handful of major metropolitan areas where geography and economic conditions are conducive to AAM market development. As such, estimates by KMPG predict 60.4 million enplanements by 2030 and a much smaller industry size.[94] Similarly, Roland Berger estimates a fleet of only 12,000 passenger eVTOL aircraft by 2030 serving much smaller total passengers.[95] However, given the current safety, technology, and integration challenges, even these projections may be optimistic. Using airport shuttle and air taxi as the scope, a recent study concluded that AAM passenger services could have a daily demand of 82,000 passengers served by approximately 4,000 four to five-seater aircraft in the US. Baselining in this most conservative scenario, these services may yield an annual market valuation of $2.5 billion.[96]

While certification, testing and evaluation process is in full swing for a few manufacturers in the US, it is important to understand rationale, demand triggers in particular, behind initial site selection for deployment of those services. ASSURE developed a framework, called site suitability analysis, to analyze demand triggers leading to likely deployment to initial sites that will be served by AAM. ASSURE research identifies five broad demand triggers: urban structure, economic scale, congestion, readiness of the service areas, and existing demand. Urban structure is represented by population density and polycentricism,[97] economic scale is represented by presence of fortune 100 companies and gross regional product or GRP or GDP by metro; congestion in metro area is captured by average time to work, drive time from airport to central business district (CBD) and an overall travel time index. Metro area readiness is represented by presence of heliports and airports per capita, presence of Class B airspace (i.e., controlled airspace), congestion in Class G (or uncontrolled airspace), magnitude of public and private investment; and finally, presence of existing demand is represented by taking into account short haul (<150 miles) origin-destination (O&D) demand in the metro area. This can be visually presented as follows:

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followed by remote supply objectives, organ transport, and then air taxis seem to be of priority and importance. Cargo transport and disaster relief followed by military missions and aerial ambulance services are likely as well [see https://bit.ly/3nBGa2w].

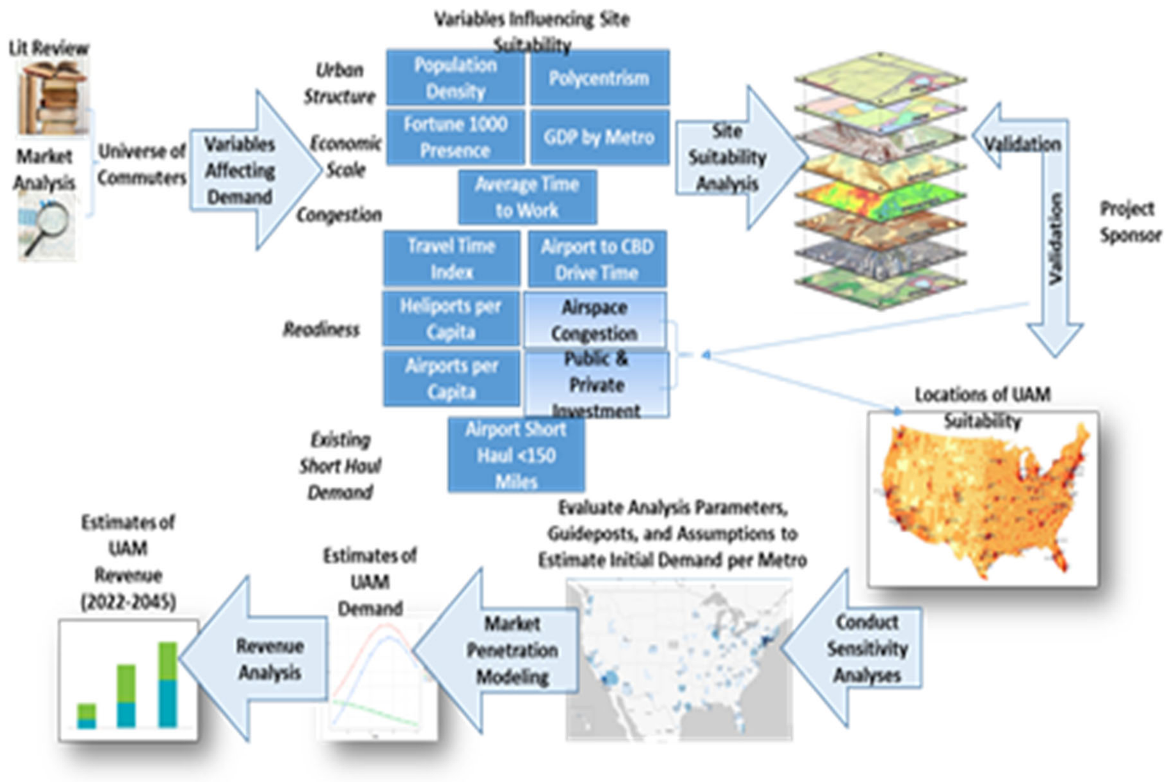
[93] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. [See https://go.nasa.gov/2C5Ten9].

[94] Getting Mobility Off the Ground, 2019, KPMG [see https://bit.ly/2WKcIcs].

[95] Urban Air Mobility: The rise of a new mode of transportation, Nov. 2018, Roland Berger [See https://bit.ly/2QVewri].

[96] Goyal, Rohit *et. al.* (2021): Advanced Air Mobility: Demand Analysis and Market Potential of the Airport Shuttle and Air Taxi Markets. [See https://bit.ly/40ErnTf for more details].

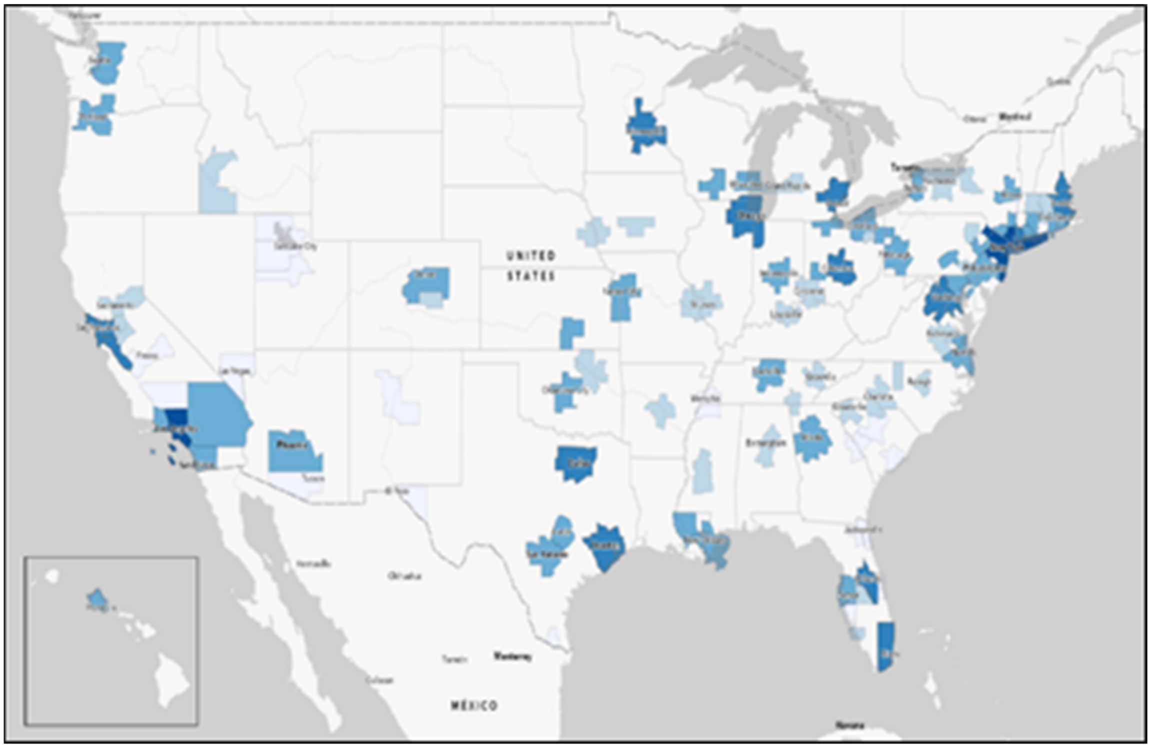
[97] Many metropolitan areas in the US and elsewhere have more than one centers of activities. For example, Washington DC metro have Baltimore to the north, District of Columbia at the core and multiple city centers in the northern Virginia in the south and southwest. Similar examples of polycentricism are abound, especially in northeast corridor of the US, Dallas, and around Los Angeles metro areas, just to name a few.



Assigning weights[98] to the variables within the broad five categories and using the above site suitability analysis framework, ASSURE identifies the following 100 metro areas for likely AAM services:[99]

[98] Values of these weights were reached at by discussing with subject matter experts within the broad ASSURE research community and the FAA through technical interchange meetings associated with this research project. Using the baseline values, ASSURE produced an excel workbook that allows alternative weight assignments leading to understanding sensitivity of location choices.

[99] Lighter shade represents relatively lower suitability while darker shade representing higher suitability.

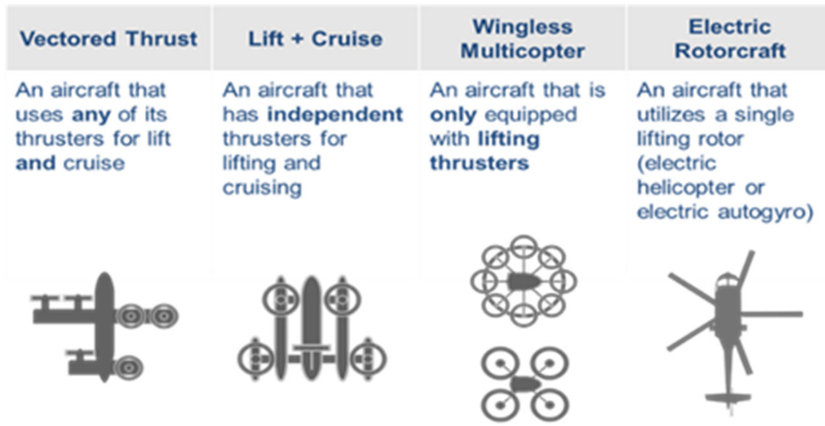


Matching the above metros against the expressed interests of the AAM OEMs and likely operating partners, mostly gathered via public statements, ASSURE identifies the following 5 likely areas of initial operations:[100]

Lauch City	Original Equipment Manufacturer and Operating Partners
Orlando, FL	Lilium (2024)
New York City, NY	Blade with BETA (2024-2025), Halo (2026), Archer and United (2025), Joby and Delta (no date yet)
Los Angeles, CA	Archer (2024), Joby and Delta (no date yet)
Marina / Santa Cruz, CA	Joby (no launch date identified)
Miami, FL	Archer (2024)

Broadly speaking, there are four types of AAM aircraft that are likely to enter into services, as reported by the ASSURE research. These are aggregated into following 4 categories:

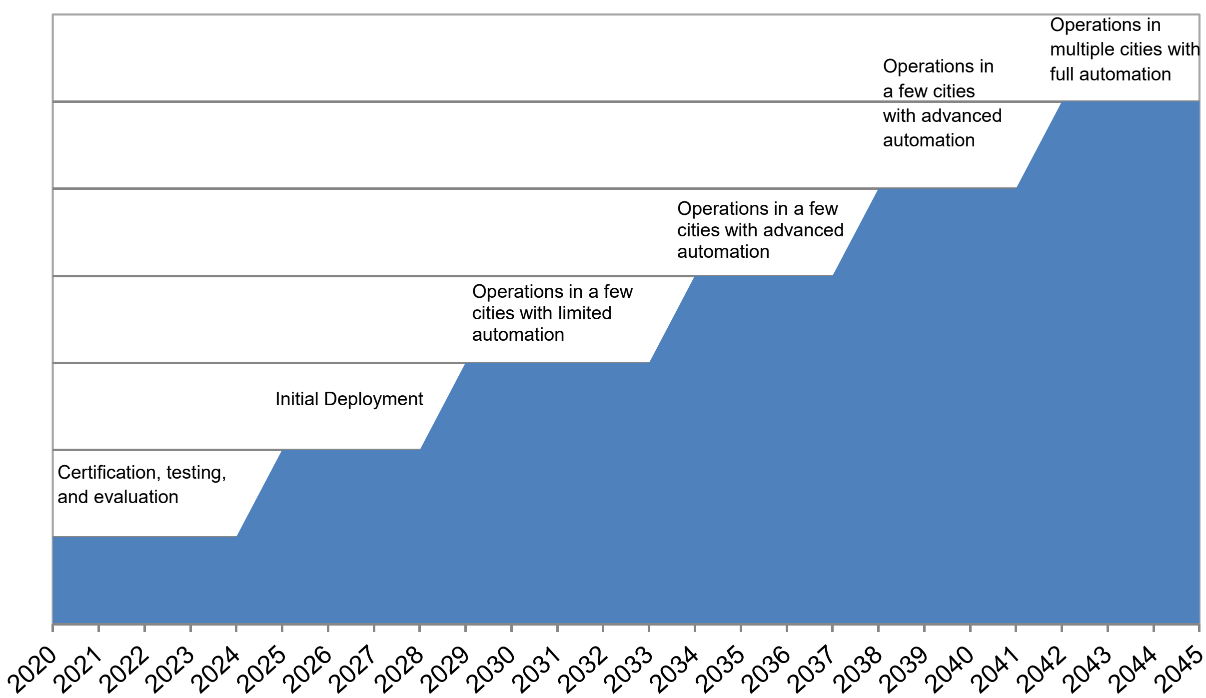
[100] Initial choice of sites will be primarily driven by OEM's business cases where demand triggers would play important roles. The framework matching demand triggers with operator-OEMs' expressed interests is intended to capture both aspects to the extent possible. For example, recent announcement of United-Archer [https://bit.ly/3ZF8deP] to begin airport shuttle services in Chicago metro area in 2025 show how operator airlines' evolving needs are matched with OEM's readiness and area-specific demand triggers.



Many of the aircraft that are quite advanced in design, testing, certification and evaluation process are of vectored thrust categories. Joby, Archer, Lilium and Vertical's aircraft fall in this category. Lift + Cruise category aircraft by Beta, Elroy, and Pipistrel are in advanced process followed by wingless multicopter design by Ehang, Volocopter, and Airbus. Finally, electric rotorcraft, i.e., electric helicopters, are designs popularized by Jaunt Air Mobility, Horizon Helicopters, Skyworks Aeronautics, IEROM, etc.

With staggered levels of automation, AAMs are likely to integrate into the NAS serving fewer cities initially scaling to multiple cities in the medium to longer run [ASSURE (2022)].

Scale of UAM Operations



Based on the research performed by numerous others, the FAA believes that AAM will likely enter into services (EIS) sometime around 2025-2026. Starting from limited services to initial launch cities noted earlier, services will be experimental, slow and likely gain a gradual trajectory of growth until 2030. We expect that initial 5 years or so will be required to resolve many outstanding issues including establishing solid AAM business cases. Depending upon the sector's resolving the outstanding issues, this will be followed by a moderate service trajectory during 2030-2040. Beyond that period, we anticipate a sustainable, mature sector on a longer-term growth trajectory.

There are numerous issues and procedural hurdles that need to be addressed in order for the industry to be on this assumed growth trajectory. Some of these may be categorized under the following broad areas:

- Safety management systems for AAM encompassing all areas of integrations;
- Requirements for operations under different weather conditions (i.e., IMC/VMC) and procedures;
- Availability of airspace capacity (400' above ground level (AGL) to 4000' AGL – likely altitude that AAM will likely traverse) in busy metro areas;
- Access to airspace via corridors and/or agreed upon community business rules (or CBRs), or letters of agreement (LOA);
- Communication issues (i.e., voice vs. digital; direct communications with air traffic control and/or via 3rd party provider of services to AAM (or PSUs) or via LOAs;
- Navigational issues involving VFR/IFR or digital flight rules (DFR) procedures;
- Infrastructure capacity particularly with respect to vertipad, vertiport, heliport, parking garages and direct access to airport;
- Issues relating to information security, surveillance and overall physical security;
- Pilot availability. It is widely believed that AAM will begin its entry into services with pilot on board. Hence, pilot availability in the short run (i.e., 5-10 years from EIS) will be critical;
- Certification requirements: following TC criteria, AAM OEMs will require production and operations certifications allowing them to mass produce aircraft and serve communities using operating certifications; and,
- Meeting other broad local, state, and federal regulations.[101]

It is important to note that the broad community has been working already on addressing many of the above-mentioned issues over the last few years. Inter-agency working group under the *Advanced Air Mobility Coordination and Leadership Act* will likely accelerate addressing and resolving the above-mentioned and policy issues faster.

Despite these outstanding issues and given the fact that the AAM services have not yet begun using the new aircraft within the US, projection of AAM demand, at best, is chal-

[101] For a discussion, see https://bit.ly/3KAbN5P.

lenging and somewhat hypothetical and arbitrary.[102] Nevertheless, drawing from ASSURE research primarily and other market analysis, we provide an estimate of base (likely; or potential adjusted by above-discussed risk factors) and lower range for departure forecasts for the years 2025-2030[103] in the table below:

			Departure Forecasts*			
	Year1	Year2	Year3	Year4	Year5	Year6
	2025	2026	2027	2028	2029	2030
Base	295,530	494,637	827,887	1,385,657	2,319,213	3,881,730
Low	206,871	346,246	579,521	969,960	1,623,449	2,717,211

*': Base (risk-adjusted potential) is based on linear interpolation of ASSURE forecasts;
Low forecast is 30% lower than base forecasts.

An analysis underlying ASSURE projection is used in preparation of NPRM for Powered-Lift rulemaking likely to be finalized sometime middle of this year.[104] In May 2022, the FAA announced that it will certify winged eVTOL aircraft as powered-lift aircraft as “special class” under its 14 CFR 21.17(b) regulations, rather than under the 14 CFR Part 23 rules used for small fixed-wing aircraft.[105] This change comes after the FAA has previously accepted several G-1 certification basis issue papers from eVTOL companies with the understanding that Part 23 rules, supplemented by special conditions, were applicable. It appears that none of the front-runners in TC process will be affected by this change in rules. For example, Archer Aviation stated that the change in FAA’s eVTOL certification approach will not impact its timeline to certify its vehicle by the end of 2024. In November 2022, Archer introduced its production aircraft, Midnight, which replaces its prototype aircraft Maker to be put forth for certification. Midnight can cover distances of 100 miles including back-to-back flights in the 20-mile range with approximately ten minutes charging time in between flights. It will have a payload of over 1,000 pounds and

[102] As reported throughout this document, the FAA routinely forecast sectors (i.e., crewed and uncrewed air transportation) for which services exist, and therefore, a great deal of data exist. For AAM services using eVTOLs, neither services nor data are available at present. However, a great deal of need, particularly for planning and allocation of scarce resources, leading to understanding the sector and its future trends is now essential. In order to meet these needs, the FAA is providing the forecasts for overall guidance. We plan to update and revise these forecasts once services begin and data become widely available.

[103] We identify 2025 as likely point of entry in time but it depends on numerous factors, some of which have been outlined above. Depending on resolution of these issues and business case for AAM continues to hold, service may begin in 2025 or soon thereafter. Furthermore, we keep the forecast horizon short to 2030 because the industry will undergo rapid changes once it begins service due to inherent dynamism and promises it holds. Hence, we keep the forecast horizon short so that we can learn from the data and revise the projected numbers and growth trajectories annually on a rolling basis, like in case of UAS sector, drawing from concurrent developments.

[104] See https://bit.ly/3Mhryjo for definition of powered-lift including the NPRM. The NPRM combines ASSURE projection with order book from OEMs for regulatory economic analysis.

[105] See https://bit.ly/3UbsyqZ. At present, FAA operating rules apply to five operational categories and associated aircraft: domestic, commuter, flag, on-demand and supplement carriers. Through the powered-lift NPRM, provided it is finalized, the FAA is proposing adding powered-lift to the list.

can carry four passengers and a pilot.[106] In December 2022, the proposed airworthiness criteria for the Archer Midnight aircraft was published in the Federal Register by the FAA.[107] Recently on March 9, 2023, Archer announced that it is nearing completion of the final assembly of its first Midnight. All major aero-structures (i.e., wing, tail, and fuselage) have been built and mated together, the company announced. A significant portion of the wiring, electronics, actuators and other systems have been installed as well. With these developments in place, Archer is currently targeting to begin flight testing of Midnight in mid-2023. This aircraft will be used to enable company testing in advance of "for credit" certification testing.[108]

In addition, the FAA is proposing a Special Federal Aviation Regulation (SFAR), 'Integration of Powered-Lift: Pilot Certification and Operations,[109] to establish temporary operating and pilot certification regulations for powered-lift. The SFAR would allow powered-lift operations to begin while the FAA collects data needed to establish permanent regulations. The FAA anticipates publishing this proposed rule in summer 2023 and will finalize it by the time the first powered-lift aircraft is certified.

Capturing only two scenarios that are comparable and drawn from ASSURE projections, we report base and low forecasts in the table above.[110] Given the impending uncertainty around EIS, assumed presently sometime around 2025-2026, likely departures may reach a level of 295,530 to begin with to a cumulative 790,000 in the base case scenario within a couple year (or by 2026 as assumed above). Assuming EIS successful, AAM departures will then likely accelerate and reach almost 3.9 million a year in a very short time (i.e., by the end of 2030), provided outstanding integration issues involving new entrants have been appropriately addressed and resolved. In lower case estimate, the likely departures are expected to be around 207,000 to a level of 553,000 cumulatively by 2026. It may likely reach around 2.7 million by 2030.

Using the distribution of AAM missions mentioned above, we anticipate these aggregate departure projections to serve airport shuttle to begin with and followed by air taxi and/or some other likely services such as air emergency, search and rescue, organ transportation etc.. Typically, these missions will fly a distance of around 60 miles, on average, at an average speed of 150 miles per hour. Distance, speed, and correspondingly, altitude profiles are drawn from the status of TC of aircraft noted above, ASSURE (2022) research and ACRP report #243. There are numerous issues outstanding with respect to pricing, performance characteristics including utilization[111] and load factors (i.e., number of revenue passengers per departures). Taking these into consideration,[112] assuming

[106] https://bit.ly/40GnUno.
[107] See https://bit.ly/436vucv for more details.
[108] See https://bit.ly/40M1Nfh for more details.
[109] See https://bit.ly/3Mi3f4O for more details.
[110] Higher scenarios will be determined by many factors including the growth trajectories following EIS, types of missions/services, expansion into many metro areas, number of departures and passengers, commercial success and successful integration into NAS. Due to much higher levels of impending uncertainties on the upside, we are leaving the upper level of forecasts out of this initial projections.
[111] For a discussion on these issues and their impact on AAM business cases, see https://bit.ly/40CbOvs.
[112] It is not conclusive to what extent lower overall load factors (e.g., dead-heading back from revenue missions) and lower utilization will impact

low load factors (e.g., 2-3 passengers per departures for lower and base cases, respectively),[113] number of passengers corresponding to departure scenarios may be calculated and are reported in the table below:

Passenger Flow* Corresponding to Departures

	2025	2026	2027	2028	2029	2030
Base	886,590	1,483,910	2,483,661	4,156,972	6,957,638	11,645,190
Low	413,742	692,491	1,159,042	1,939,920	3,246,898	5,434,422

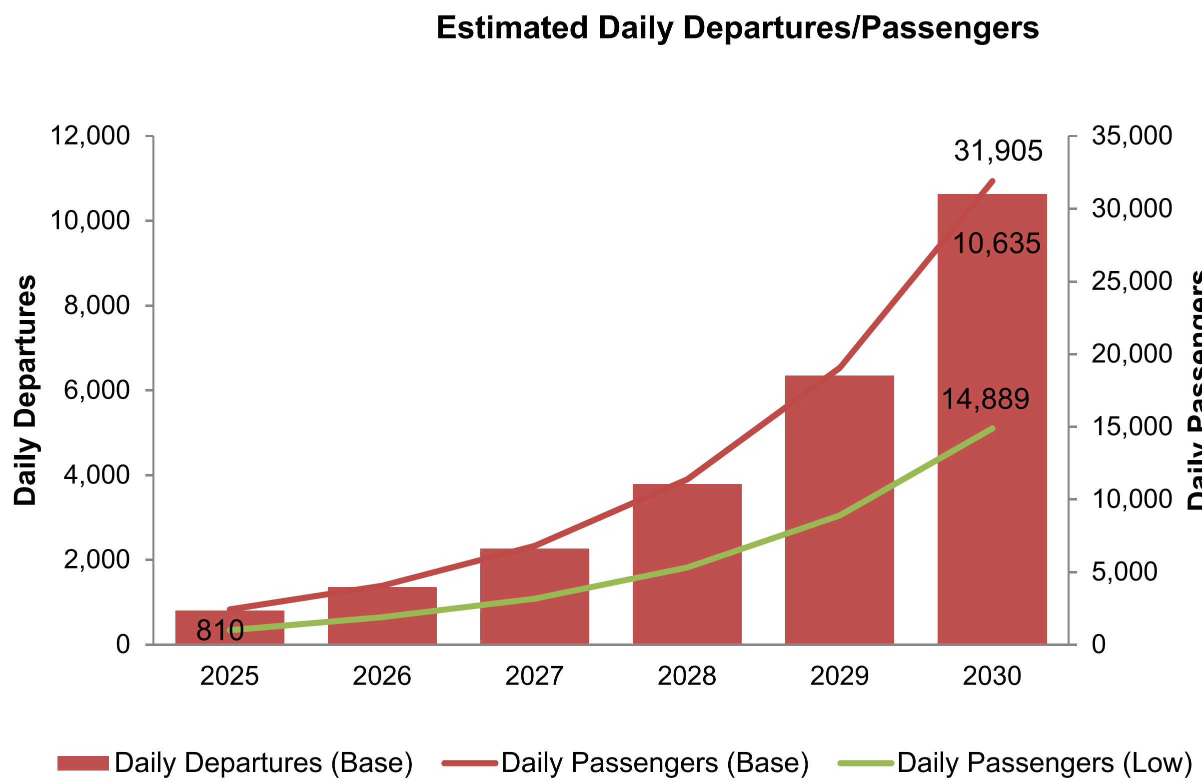
*: 3 passengers per departure and 2 passengers per departures corresponding to base and low forecasts, respectively.

Starting from an anticipated 887,000 passengers annually, a cumulative 2.3 million passengers may be reached soon after EIS by 2026 in the base case scenario or risk-adjusted potential scenario. In lower range, passenger levels may reach cumulatively over 1 million passengers by 2026 driven by assumptions of lower number of departures and load factors.

Translating the above annual numbers to daily departures/passengers (e.g., total departures and passengers divided by 365 days), in base case scenario, we calculate a few hundred departures transporting a few hundreds to around 2,400 passengers daily to begin with in 2025. Around 2,100 cumulative daily departures transporting around 3,000-6,500 cumulative passengers (i.e., lower to base cases, respectively) may be attained soon after by 2026. It may likely reach a level of over 10,000 daily departures in base case transporting around 15,000 daily passengers in lower range to around 32,000 in base case scenario in 2030.

business cases negatively and thus may jeopardize services altogether. Many assumptions have been made, and at this point, the FAA is not certain how pricing, lower load factors or utilization of aircraft, types of services and market adoption, supply chains, funding, manufacturing and role of operating partners, infrastructure including access to airspaces and airports/vertiports will ultimately impact the business cases of AAM services. As more information become available in the future via research, and information from the industry, we plan to improve on these initial projections going forward.

113 Generally speaking, eVTOLs are assumed to have, for majority of vehicles that have been presently designed (over 200), one to four passengers with one pilot on board. On average, trips are expected to have a passenger load of three riders for airport shuttle, as reported by market studies accounting for the shared route model of Air Metro [see https://bit.ly/40Wik0t].The base case reported in the table (i.e., 3 passengers) draws on this recent finding. However, air taxi is expected to have much lower passenger load (1 passenger) due to on-demand nature of services and associated mobility flexibility.



Number and frequency of missions, distance/time, recharging, maintenance time, and average daily utilization hours for these eVTOL vehicles will determine the number of aircraft needed to serve the calculated departures projected in earlier table. Intra-urban and inter-urban swap of aircraft will be determined by distance, relative demand, and performance characteristics. Number of station-specific and time of the day aircraft can also be estimated from the above daily distribution and utilization of aircraft.

Both number of departures and passengers are relatively small in comparison to likely latent demand. For example, there are closer to 225 individual annual trips commuting to work and over 400 average annual trips visiting family and friends for 40 miles or less. In aggregate, these add up to 200 million trips per year by car for shorter distances in the US.[114] It is reported that there are perhaps 14 million a day Uber/Lyft trips. An average of 45,000 flights/day serve over 2.9 million passengers in the US.[115] In addition, there are over 9,000 commercial helicopters in the US.[116] All of these may likely provide strong

[114] See https://bit.ly/2C57w77 for this calculation. Not all of these trips, either commute to work or visiting friends/families, can be substituted by AAM air taxis. It merely indicates the size of the substitution magnitude for calculating latent demand for AAM.

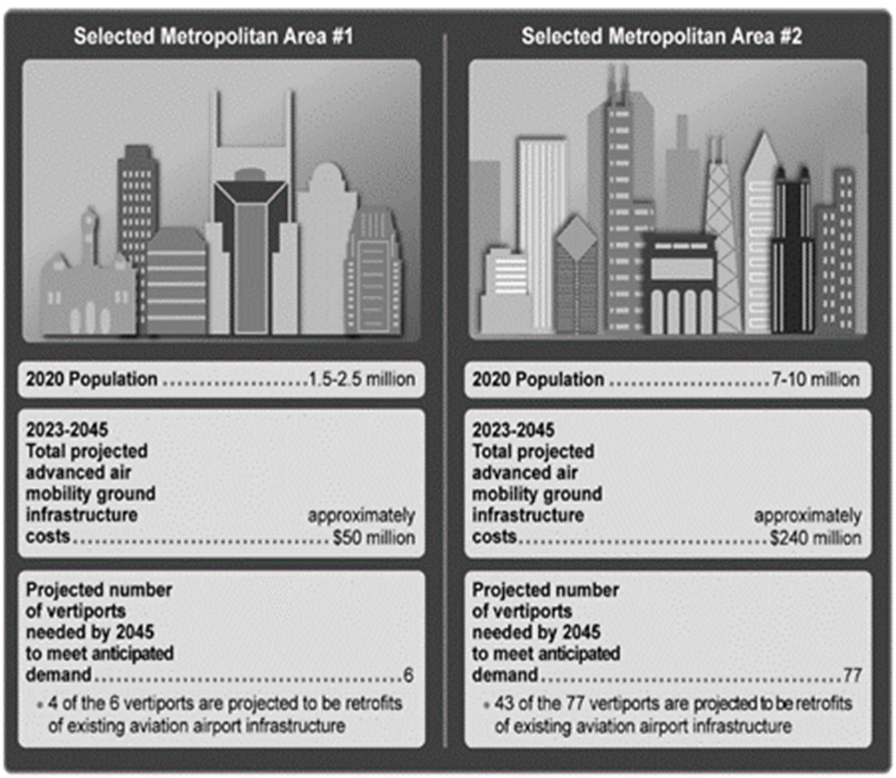
[115] https://bit.ly/3m0vfPL.

[116] See https://ushst.org/.

demand pull factors for airport shuttle to begin with followed by air taxi.

Despite our efforts to provide initial projections of the AAM sector, there are numerous factors that may possibly create a shroud of uncertainty around the numbers discussed above. One of the major challenges of eVTOL entering into the marketplace is infrastructure. In a recently published report, GAO (2022)[117] estimates that for smaller metropolitan areas (1.5-2.5 million population), 6 vertiports will be needed while for larger metro areas (7-10 million population), the numbers may go up as high as 77. Total estimated ground cost for smaller metro areas have been estimated to be $50 million while for larger metros, it is almost 5-times higher at $240 million. ASSURE (2022) reported that an estimated 75-300 vertiports will be required for each metro area. In total, ASSURE estimates 2,500-3,500 vertiports will be needed to establish a mature AAM passenger network nationwide in the US. Costs involving setting up such network will be expensive as reported in GAO report and elsewhere:[118]

Figure 6: Examples of Projected Capital Costs and Vertiport Needs for Two Selected Metropolitan Areas



Source: GAO analysis of UAM Geomatics projections as of January, 2022. | GAO-23-105188

In order to increase accessibility of vertiports for AAM services, air taxi operators have been evaluating different approaches to expand the potential network of vertiports or takeoff and landing areas (TOLAs). In 2021, both Joby and Archer entered into partnerships with parking garage operator REEF Technology with the goal of running air taxi

[117] GAO (2022): Transforming Aviation: Congress Should Clarify Certain Tax Exemptions for Advanced Air Mobility; GAO-23-105188.

[118] See ASSURE (2022) for a detailed discussion drawing on the existing literature.

operations from the rooftops of redesigned parking garages.[119]

The infrastructure constraint—the availability of desirable TOLAs—will be a challenge for scaling AAM operations, as they require community acceptance and affect issues relating to social equity, noise and environmental impacts. NASA is leading research in these areas, and in 2021 it released a report with NUAIR (Northeast UAS Airspace Integration Research Alliance, Inc.) and industry describing a concept of operations for high density vertiport operations.[120] Recently, the FAA issued an engineering brief providing interim guidance to airport owner/operators and their support staff for the design of vertiports for vertical takeoff and landing operations.[121]

Other than eVTOL operators, some companies are focusing on developing the infrastructure needs which require partnering with local governments and property owners to locate and acquire sites for future vertiports. For example, Urban-Air Port, a UK-based startup, announced in January 2022 that it plans to develop 200 vertiports for eVTOL flights in 65 cities to accommodate the anticipated AAM demand.[122] Leaders in AAM infrastructure development include Groupe ADP and Ferrovial. Groupe ADP is creating infrastructure for eVTOL air taxi flights to be introduced in Paris when it hosts the 2024 Summer Olympics. In November 2022, Groupe ADP signed MOU with government officials in Abu Dhabi to plan, design, develop, and operate vertiport infrastructure for future eVTOL services in Abu Dhabi. Ferrovial is a infrastructure group headquartered in Spain but has its vertiport division based in Irving, Texas. Ferrovial has been partnering with Lilium since 2021. In 2022, Ferrovial and AECOM (an engineering firm) to identify optimal sites to launch a vertiport network in Florida in 2024 or 2025.[123]

Engagement with airport operators is essential, especially when airport shuttle is the focus of the service. A recent Airport Cooperative Research Program report (#243) called “Urban Air Mobility: An Airport Perspective (2023)” laid out a comprehensive framework of market assessment capturing three AAM use cases; UAM for passenger air mobility, air cargo and emergency services. Assessments show substantial growth potential across use cases with implications for airport applications. The report was initiated to devise a strategy for engaging with airport stakeholders to better understand their perspectives, market readiness, views of policy, and planning considerations regarding the operational integration of UAM into daily airport activities. Incorporating different UAM use cases, a guide and toolkit were created as companions to present key considerations deemed essential to support airports in navigating the likely UAM entrance into airports. The guide is anticipated to assist airport practitioners as they engage in an iterative process to understand how this emerging marketplace with three use cases should factor into their business plans, community engagement, master planning, and decision making framework.[124]

Finally, there is also Congressional support in developing AAM infrastructure. The Advanced Aviation Infrastructure Modernization

[119] https://bit.ly/3ZHz2io.
[120] https://go.nasa.gov/40RxJi2.
[121] See https://bit.ly/4351vBK for more details.
[122] https://bit.ly/3MkTaUy.
[123] https://bit.ly/4381ooU.
[124] See ACRP Report #243: Urban Mobility: An Airport Perspective (2023); available at https://bit.ly/3U95DfU.

(AAIM) Act was passed by the US House of Representatives on June 14, 2022.[125] The bill provides $25 million in grants over two years to plan and build vertiport infrastructure. There are other opportunities, such as Pilot Program in Postal Banking[126] that may hold promises and guidance for accommodating AAM infrastructure needs, particularly in rural areas.

Due to uncertainties associated with numerous issues such as certifications (i.e., type, production, and operations) and infrastructure including integration to airspace, market revenue estimation for the overall sector has been quite wide. As noted earlier, the total available market for passenger services is estimated to be $500 billion in the United States, but AAM is unlikely to garner more than $2.5 billion of this market in the near term, as previous studies estimate.[127] On the upside of the estimation, a recent study conducted by Deloitte and the Aerospace Industries Association (AIA) estimates the AAM market in the US to reach approximately US $115 billion by 2035, equivalent to 30% of the present US commercial air transportation market.[128] Of that total, US $57 billion is expected to originate in passenger air mobility, while an equivalent amount is expected to come from the cargo market. Finally, Morgan Stanley's eVTOL/UAM total addressable market (TAM) estimates revenue to be around $2.5 trillion in 2050.[129]

In comparison, ASSURE estimated revenue to be modest; at around $150 million in around 2025-2026 that is likely to reach around $2.7 billion in 2030. Combining these revenue projections with departure and passengers forecasts reported above, average fare per passengers is calculated to be around $80-$120 corresponding to base and lower range cases, respectively. Recent service announcement[130] implies price (i.e., around $136-$200 for a full cabin of 4 passengers or $34-$50 per person] to be around half that ASSURE-implied prices calculated from revenue estimates.[131]

Market dynamics underlying AAM are complex, numerous, and quickly evolving. COVID-19 has led to an increased adoption of virtual work versus commuting and business travel. However, persistence of this trend in the long-run is mired in uncertainty.[132] Socioeconomic and spatial

[125] See https://bit.ly/3ZBg9xP.
[126] See https://bit.ly/3zwB6PL for more details.
[127] UAM Market Study – Technical Out Brief, Oct. 2018, Booz-Allen-Hamilton and NASA. [See https://go.nasa.gov/3GjAYa1. See also Goyal *et. al.* (2021) reported earlier]
[128] https://bit.ly/3Ku0xaV.
[129] See Morgan Stanley's eVTOL/UAM TAM Revenue in 2050; Base case only; See https://mgstn.ly/35JTCnv.
[130] See https://bit.ly/3ZMllPb. Furthermore, Blade with existing services in many parts of the country including the NYC reported first successful completion of a historic piloted test flight of BETA's ALIA-250 electric and vertical aircraft (EVA) at the Westchester County Airport in White Plains, New York on February 14 this year. Blade reported it to be a significant milestone towards transition from its use of helicopters to EVA in the near future [see https://bit.ly/3lZgAUY for more details].
[131] Research studies, industry reports and analysis tend to suggest a broad range of price estimates with varying effects on AAM demand: $2.25 per seat mile to as much as $11 per seat mile as summarized and reported here: https://bit.ly/3KySwS6.
[132] Road congestion and associated opportunity cost in commuting around metro areas provided the most powerful boon for economic and financial justifications for AAM passenger services. However, changed working pattern due to working from home (WFH) caused by COVID19 put a damper on that earlier economic trade-off, at least in the near-term. McKinsey reported results of a survey from last year (2022) of workers

changes such as population shifts from urban to suburban or rural areas (i.e., de-urbanization) could also affect the various AAM use cases differently. AAM services, both cargo and passenger, may appear to be unprofitable in the near future, like many other services in the beginning. The AAM passenger industry is likely to expand driven initially by an inflow of venture capital and experimental services exploring market opportunities. For example, following the numerous SPAC mergers for AAM companies two years ago, which injected significant capital to further their development and commercialization efforts, Wisk Aero secured an additional $450 million investment from Boeing in January 2022. Volocopter has also recently entered into an agreement that may provide up to $1 billion in financing.[133] Additionally, eVTOL operators like Joby are expanding partnerships to operate air taxis in international markets[134] and many companies are experiencing rising interest and increased orders of their eVTOL aircraft, both in the US and globally.[135] However, as the capital markets tighten with successive rises in federal funds rate,[136] securing capital would become challenging and making business cases for AAM more demanding. According to McKinsey & Company, the broad industry[137] saw a significant decline, for example, in funding in 2022 compared to 2021. The industry saw $3 billion invested in 2022 compared to $7 billion reportedly invested in 2021 due to reasons of global economic slowdown, and the reduction in investment by SPACs.

Order book, on the other hand, appears to be still robust, according to McKinsey & Company, with 6,700 pending orders worth $45 billion. While many of these orders are non-binding, the increase as well as interests from airlines, aircraft charter, and leasing companies may demonstrate the commercial appeal and inner strength of the AAM business cases.[138]

Given the enormous economic potential underlying the AAM sector, coordination led by the FAA, in close collaborations with NASA and the industry, is allowing numerous integration activities to take place presently. For example, under NASA's National Campaign (NC), working groups drawn from the FAA, NASA, and numerous stakeholders are focusing on understanding the four key areas of AAM integration: aircraft, airspace, community integration, and cross-cutting areas. Complimenting this effort, the FAA created an internal AAM Integration Executive Council, and is actively working with internal and external stakeholders to understand the nature, scope, and likely evolutions of AAM.[139] The FAA also issued a concept of operations

(N=13,896) in the US [see https://mck.co/413Akph] that drew the following observations: 58% of the labor force (or, 92 million) say that they can work remotely at least part of the time; and around 35% (or 55 millions) WFH on a full time basis. Based on these findings and analysis, the McKinsey predicts that flexible work arrangements are here to stay for longer period. Flexible work arrangements may change the earlier economic trade-offs underlying AAM, applicable particularly in air taxi use case.

133 https://bit.ly/3mbpoHd.

134 https://bit.ly/40ZbBCf.

135 https://bit.ly/3m4Chmt; for a partial list of passenger eVTOL A/Cs orderbook at the end of December, 2022, see https://bit.ly/40K2aXK.

136 See https://bit.ly/3KyjN7e.

137 Includes sustainable aviation using hydrogen cells, supersonic aircraft, passenger eVTOL aircraft, surveillance and cargo drones.

138 For a partial list of passenger eVTOL A/Cs orderbook at the end of December, 2022, see https://bit.ly/3ZBwSRD.

139 See https://bit.ly/3nKJLeR.

(CONOPS) in June 2020,[140] and is likely revise it and also publish a strategic implementation framework in the near future. Furthermore, NASA issued AAM CONOPS corresponding to slightly advanced maturity levels—Urban Air Mobility Maturity Level 4 recently.[141]

All these activities are facilitating an evolving operational framework for gradual integration of AAM into the NAS; e.g., flight testing of AAM vehicles at NASA,[142] AAM playbook,[143] high-density vertiplex,[144] regulatory coordination for safety, traffic management, and international harmonization with other agencies, e.g., European Union Aviation Safety Agency (EASA) leading to type certifications.[145]

These proactive steps are positioning the AAM industry positively towards realizing market opportunities. In December 2020, for example, Joby Aviation received the first airworthiness approval by the US Air Force (USAF) for an eVTOL aircraft under Agility Prime and now increased potential value of the total contract to more than $75M. Partnering with Delta Air Lines on the other hand, targeting airport shuttle in New York and Los Angeles, Joby received an upfront equity investment of $60M, thus totaling investment from Delta to $200M.[146]

In November 2022, Archer and United Airlines announced first commercial electric air taxi route in the US: from southern tip of Manhattan to Newark Liberty International Airport.[147] In similar vein, American Airlines has reserved delivery slots and secured pre-delivery payments for 50 of Vertical's VX4 eVTOL, the first of its kind for a major airline in the eVTOL market[148] American Airlines has also placed a conditional preorder of up to 250 of Vertical's aircraft in June 2021, with an option for an additional 100 units. Lilium GMBH, a German company, is developing an eVTOL transport network centered on Lake Nona in Orlando, Florida. It has partnered with the City of Orlando and a real estate development company to establish a vertiport hub in Lake Nona by 2025. It will be used for regional, inter-city air mobility services, with travel distances of up to 186 miles in 60 minutes by Lilium Jet aircraft currently under development.[149]

The trend is somewhat similar at the international level as well. For example, EHang, a Chinese manufacturer of autonomous aerial vehicles (AAVs), established a strategic partnership with UAM pilot cities in Spain, Austria, and China in 2020.[150] It also conducted demonstration flights in South Korea with its two-passenger autonomous aerial vehicle, the EHang 216. German AAM companies, Lilium and Volocopter, are also working to launch passenger air transport services within the next few years. Volocopter completed demonstration of air taxi flights in Singapore in 2019 and began to sell tickets for

[140] Available here: https://go.nasa.gov/3GjrcEV. Revised version (2.0) is expected this spring.
[141] See https://go.nasa.gov/3Kykopu for more details.
[142] See https://go.nasa.gov/3MgSyza.
[143] See https://go.nasa.gov/3mcXz15.
[144] See https://go.nasa.gov/3KxT5LS.
[145] See, for example, https://bit.ly/40YxuBU.
[146] https://bit.ly/3KxNgyd.
[147] https://bit.ly/3UgPjtO.
[148] https://bit.ly/3MgSXBG.
[149] https://bit.ly/3Min8Zw. Similar developments involving others are abound in the US. FAA routinely collects these information to the extent they are useful for understanding broad market developments and forecasts.
[150] https://bit.ly/3U6ERoB.

commercial service, expected to start in Singapore by 2023.[151] Volocopter has also announced plans to introduce air taxi services in the US.

AAM services are likely to face stiff competition from technological advances in industries with close substitutes, such as ground transportation (i.e., emerging automated solutions on increasingly electric-powered vehicles). Furthermore, economic and financial tradeoffs underlying the emergence of AAM may have changed following COVID-19, changing travel patterns and perhaps long-term living arrangements. Finally, the high costs of urban infrastructure, community acceptance, associated noise, and environmental issues pose considerable challenges for AAM TC, PC,[152] and eventual community acceptance leading to greater adoption. Future AAM operators are also expected to comply with new operating requirements and other regulations yet to come.

Despite these challenges, state, local, and regional governments are aligning themselves with the manufacturers and likely operators. For example, the city of Los Angeles announced the creation of its Urban Air Mobility Partnership in December 2020. It is a public-private partnership, called Urban Movement Labs that will evaluate barriers and solutions leading towards facilitating air taxi services in Los Angeles by 2023 and broader uses during Olympics games in 2028.[153] In August 2022, Ohio published its first AAM framework.[154] In February, 2023, the Virginia Innovation Partnership Corporation (VIPC) with the State of Virginia's Office of the Secretary of Commerce and Trade published an economic impact study of AAM.[155] Other entities, including the Canadian AAM Consortium (CAAM,) have also studied the impacts of AAM on regional economies.[156]

In order to facilitate AAM entry into local transportation networks, numerous local and state entities have begun the process of preparing and self-identifying as early adopters.[157] Furthermore, targeting invest-

[151] https://bloom.bg/3m9Tj2o.

[152] Recent agreements of Archer with Stellantis [https://cnb.cx/3Gd4Rcb], Lilium with GKN Aerospace [https://bit.ly/3ZJki2u] and likely others, perhaps Joby with Toyota, to mass produce aircraft indicate that the OEMs are positioning post TC stages to production and routine operations. Archer with Stellantis, for example, have been working to stand up manufacturing facility of 350,000 sq. ft. in Covington, Georgia, to begin producing 650 Midnight four-passenger eVTOL aircraft/year in 2024 [see https://bit.ly/3nAmdZV]; and BETA Technologies, manufacturer of ALIA-250, has been making progress on its 188,500 sq. ft (phase 1) for its aircraft assembly facility in South Burlington, VT. Globally, Eve announced plans in December, 2022 for its initial production facility to be co-located at an Embraer facility in Brazil. The modular design of the site, when built, will allow for a gradual scaling up and production of up to 250 eVTOLs per year, an attainable target. On April 5, 2023, Volocopter announced opening of a new hangar that will host the company's final assembly line with an airfield to conduct development flight tests as well as quality checks. Volocopter's production facilities in Bruchsal will have the capacity, and importantly the regulatory approval, to assemble 50+ VoloCity aircraft each year to deploy around the world [see https://bit.ly/3zSIQMl for more details].These demonstrate the seriousness of the efforts by OEMs. We expect similar steps in setting up manufacturing facilities to follow from other OEMs as well.

[153] https://bit.ly/3Kymiq8; see also https://bit.ly/3Gj9Tnw.

[154] https://bit.ly/4335Q8t.

[155] https://bit.ly/3U9abD2.

[156] https://bit.ly/3Kygo8o.

[157] See https://go.nasa.gov/433wFJQ.

ments in regional air mobility (RAM) by utilizing the country's vast underutilized airport infrastructure may compliment and accelerate local and state initiatives on emerging markets, including those targeted by AAM, likely transforming the entire NAS in the future.[158]

As the sector is initiated with initial entry into services outlined in this section, new initiatives will be undertaken with new missions envisioned and operationalized. The FAA, together with numerous stakeholders including the industry, and NASA will be keeping a keen eye on understanding overall trends in AAM. It is likely that AAM services will become a reality in the US by 2025-2026 and will become incrementally available in urban and suburban areas followed by an accelerated growth trajectories targeted to reach farther and distant travel destinations and routes over time. With this anticipated travelscape imagined and drawn for the next few years, as more information becomes available, the FAA will revise emerging trends and forecasts for AAM reported in this section in the near future.

[158] See https://go.nasa.gov/3m9Ulvi for more details.

Forecast Uncertainties

The forecasts in this document are forecasts of aviation demand, driven by models built on forecasts of economic activity. There are many assumptions in both the economic forecasts and in the FAA models that could affect the degree to which these forecasts are realized. This year's forecast is driven, at least in the near-term, by the pace of recovery from the impacts to the U.S. and global economies and the aviation industry resulting from the novel coronavirus (COVID-19). It does go without saying that terrorism remains among the greatest world-wide risks to aviation growth. Any terrorist incident aimed at aviation could have an immediate and significant impact on the demand for aviation services that could be greater than its impact on overall economic activity.

In addition, changes in the geo-political landscape could lead to outcomes very different than the forecasts provided in this document. The ongoing crisis in Ukraine represents a very large uncertainty to this year's forecast. The impacts are still evolving and dependent in large part on the outcome of the armed conflict in Ukraine. While there was an initial negative impact on airline bookings as well as a surge in oil prices, those impacts have diminished over time. The impact of the economic sanctions on Russia have pushed the Russian economy (the world's 12th largest as of 2021) into a sharp and prolonged recession that may have broad spillover effects to the global economy. European economic growth slowed in 2022 as Europe moved to restrict trade with Russia and its allies, and reduce its dependence on energy from Russia. Many forecasters see continued low European economic growth in 2023 as well due to the impacts of the conflict. In the longer run, most analysts are seeing a return to higher tensions between Russia and the West resulting in higher expenditures on defense that may push taxes higher, and leave consumers with less money to spend on items like air travel.

The rapid spread of the novel coronavirus (COVID-19) that began in early 2020 resulted in the largest decline in aviation activity since the jet era began in the late 1950's. While aviation activity has almost fully recovered to pre-pandemic levels, there is still a good deal of uncertainty about the long run path of aviation activity once the recovery from the 2020 downturn is complete. There are questions as to whether or not the strategies that U.S. and foreign carriers are employing to recover from the downturn in demand will be successful in a post-COVID environment. Other questions surround the stability of consumer attitudes and behaviors towards aviation in a post-COVID environment, as well as the breadth and depth of the and the speed and nature of the economic recovery, all of which apply both domestically and globally.

The future direction of oil prices presents another considerable uncertainty in producing the forecast. The FAA's baseline forecast (derived from economic assumptions in IHS Global Insight's December 2022 U.S. macro forecast and 30-Year Focus released during December 2022) calls for oil prices to fall from $95 per barrel in 2022 to $75 per barrel in 2023. Over the long term, the FAA baseline forecast assumes that oil prices will rise gradually to about $91 per barrel in 2030 and about $118 per barrel by the end of the forecast period in 2043. However, there are other oil price forecasts that are considerably more aggressive than the FAA base forecast such as the latest Energy Information Administration (EIA) Annual Energy Outlook released in March 2023. By 2030, it anticipates the spot price of oil will reach $106 per barrel and by 2043, $153 per barrel, considerably above the FAA base forecast of $118. Over the long run, lower oil prices give consumers an impetus for additional spending, including air travel, and should enhance industry profitability. In the case where oil prices turn out to be higher than the FAA forecast, we would expect lower spending on air travel by consumers, higher costs for fuel to airlines and reduced industry profitability.

The baseline forecast incorporates additional infrastructure spending in 2023 and beyond. However, there is considerable uncertainty as to the magnitude, timing, and nature of these programs that ultimately determines the impact on the future growth of the U.S. economy. In addition, how the U.S. will engage with the rest of the global economy over the next several years continues to evolve. Under the right conditions, a period of sustained high and more inclusive growth along with increased financial stability could occur. However, in light of the recent Russia-Ukraine conflict there is an increased possibility of an outcome that leads to greater global economic fragmentation due to rising tensions resulting in slower growth, and increased financial instability.

The baseline forecast assumes that the global economic recovery that began at the end of 2020 will continue but at a slower pace in 2023. Thereafter, the baseline forecast assumes that China and India will be growth engines for emerging economies. The forecast assumes China successfully transitions the economy from heavy reliance on manufacturing and resource industries to one more oriented towards the services and technology sectors and India continues to implement reforms to make its economy more competitive. Many analysts are concerned that in light of the Russia-Ukraine conflict, China moves closer to Russia, limiting opportunities to further transition its economy away from manufacturing and resource intensive industries. In the case of India, the impact of the Russia-Ukraine conflict on energy prices and food prices may put pressure on trade and fiscal deficits resulting in a slowdown of reforms.

In the United States, economic growth in the near term is expected to be slow as the impacts of the Federal Reserve's moves to reduce inflation by raising interest rates are felt by consumers and businesses. The forecast anticipates that inflation returns to acceptable levels by 2024. Over the forecast horizon economic growth (real GDP) remains below 2 percent as population growth and productivity growth remain lower than historic averages. The forecast does not assume any measure of fiscal restraint will be implemented, despite government debt as percent of GDP exceeding 100 percent and approaching levels that were last seen at the end of World War 2. In Japan, the United Kingdom, and the European Union economic growth over the next few years will be well below rates seen over the past few years as these regions recovered from the COVID-19 recession. Demand growth will remain slow in these regions over the forecast horizon as they continue to be constrained by structural economic problems (high debt, slow population growth, weak public finances, for example) and political instability. In most of the major advanced economies, governments need to shore up their finances after the increases in government spending to offset the impacts of COVID-19. There exists a nontrivial possibility that authorities will either act prematurely or be excessively timid and late in taking necessary steps to maintain a healthy global economy. The current forecasts call for strong passenger growth for travel between the United States and other world regions, especially over the next few years. An unexpected slowing of worldwide economic activity could push the return of international passenger demand to pre-COVID levels beyond our current forecast of 2024.

Although U.S. airline finances have been decimated as a result of COVID-19 and the fall in demand, the outlook for further consolidation either through mergers and acquisitions (M&A) or bankruptcy appears to be rather limited, with one exception: a planned merger between JetBlue Airways and Spirit Airlines, pending regulatory approval. Ultra low-cost carriers which focus on domestic leisure traffic have been fastest to recover during the pandemic, putting them in relatively strong positions in recent quarters, and creating the opportunity for a merger. Based on FY 2022 data, the top 6 (American, Delta, United, Southwest, Alaska and JetBlue) accounted for about 82 percent of the U.S. airline industry capacity and traffic, and a combined JetBlue and Spirit would make up about 10 percent. For the large network carriers, the steps they have taken to increase their liquidity have reduced the risk of bankruptcy in the next few years. However, if the demand recovery is slower than expected, the increase in debt that these carriers are servicing may be a burden and increase the possibility of a bankruptcy or liquidation. While the announced merger of JetBlue and Spirit shows that in the right circumstances, consolidation among low cost carriers can happen, in general, the risk associated with a merger today compared to pre-COVID has increased due to the poorer financial condition of carriers.

The forecast assumes the addition of sizable numbers of large regional jets (70 to 90 seats) into the fleets of regional carriers. While the recovery in air travel demand from the COVID downturn is projected to be robust, we are not projecting a uniform recovery across all segments. As network carriers continue to adjust the size and breadth of their networks in anticipation of the post-COVID environment, they are continuing to move forward with plans to significantly reduce the numbers of small regional jets they will need. Prior to the COVID downturn in 2020, strong air travel demand has not ensured financial stability for regional carriers, as the bankruptcy filings of Republic Airways in 2016, Great Lakes Airlines in 2018 and Trans States Airlines in 2020 have shown. Financially strong and well positioned regional carriers may see increased opportunities for regional flying as a result of the network carrier actions, but the overall impact will most likely reduce opportunities for many regional carriers. In addition to managing changing relationships with network carriers, regional carriers have struggled with pilot shortages that were exacerbated during the pandemic recovery. The downturn prompted mainline carriers to reduce costs by, among other measures, offering voluntary retirements to flight crews but, as activity picked up, they drew replacements from the ranks of regionals, causing additional shortages for those carriers. To attract and recruit crews, some carriers have raised salaries and offered bonuses, further increasing financial pressures and possibly leading to new consolidation in the regional airline industry.

The general aviation sector did suffer a downturn in activity in 2020 due to the impacts of COVID-19, but the magnitude of the decline was much less than the decline in commercial aviation. By the end of 2021 most sectors, including corporate and business aviation, were at or exceeding pre-COVID activity levels and GA flight hours exceeded pre-COVID levels. Once returning to pre-COVID levels of activity, future growth in business and corporate aviation is based largely upon the prospects for economic growth and corporate profits. Uncertainty in these leading indicators poses a risk to the forecast, but the risk is not limited to these factors. Other influences, such as potential environmental regulations and taxes do not seem to be as much of a concern in the short term, but over the long term, uncertainties about the direction of these influences may place downward pressure on the forecast.

Overall activity at FAA and contract towers rose 10.2 percent in 2022, while activity at large and medium hub airports (64 in total) increased 24.2 percent and 14.9 percent, respectively, in 2022, leading to a summer of congestion and delays. While FAA's baseline forecast calls for operations at FAA and contract towers to return to pre-COVID levels of activity by 2023, in the long run, operations at large and medium hub airports grow faster than the overall national trend and congestion and delays could become critical limits to growth over the forecast period. FAA's forecasts of both demand and operations are unconstrained in that they assume that there will be sufficient infrastructure to handle the projected levels of activity. Should the infrastructure be inadequate and result in even more congestion and delays, it is likely that the forecasts of both demand and operations would not be achieved.

Not only is the volume of aircraft operating at most large hubs expected to increase over the next 20 years, but the mix of aircraft is changing for this same period. The expected increases in the numbers of larger regional jets and business jets as well as the anticipated widespread deployment of UAS and Advanced Air Mobility (AAM) vehicles into the national airspace system will make the FAA's job more challenging. For example, in adding these new vehicles to the system, they could replace existing traditional aircraft. This change in the mix of aircraft will most likely add to workload above and beyond the increasing demand for aviation services resulting from the growth in operations over the forecast period.

Increasing concerns about aviation's environmental impacts could potentially limit or delay the ability of the aviation sector to grow to meet national economic and mobility needs. Airspace modernization and airport expansion or new construction are often contentious because of concerns over noise, air quality, and water quality. Climate change is also of concern and could limit aviation growth. In Europe, concerns about climate change are leading to restrictions on airport expansion activities and proposals to limit short-haul domestic flights. Community concerns across the U.S. about aviation noise have led to increasing levels of public debate, political interest, and even litigation. Without effective measures to mitigate and abate aviation noise, the infrastructure projects and airspace redesign efforts needed to support currently forecasted aviation growth may be delayed. Similarly, community concerns about environmental and/or other considerations (e.g., privacy concerns) associated with UAS, AAM, and commercial space launch activity could impact growth in these aviation areas.

In addition to providing economic benefits, technologies to improve aircraft fuel efficiency and reduce fuel consumption provide benefits in terms of reduced emissions that impact air quality and climate change; many technologies that improve fuel efficiency also result in reduced noise. Airlines are increasing their use of sustainable aviation fuels, which provides benefits in terms of reduced impacts of aviation on climate change and air quality. The implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a global market-based measure for international carbon dioxide emissions, will help ensure an approach that is economically preferable to a patchwork of State or Regional-level regulations around the world is used, and will help to further address the impacts of aviation on climate change. Industry, the U.S. government, and international aviation, through ICAO, have all set an ambitious goal of moving the sector to net zero carbon dioxide emissions by 2050. Continued advancements and fleetwide uptake of sustainable aviation fuels and new aircraft and engine technologies that result in improved fuel efficiency, reduced fuel consumption, noise reduction and reduced emissions are required to ensure that access restrictions or operating limitations are not imposed on the in-service fleet, which in turn may dampen the growth of civil aviation.

Widespread deployment of UAS and AAM vehicles, and the electrification of conventional general aviation and short haul aircraft are other potential near term tools for reducing aviation emissions, provided they replace traditional aircraft in the movement of people and goods and their power requirements are met using sustainable sources. Otherwise, such vehicles would result in a net life-cycle increase in environmental impacts. The expansion of commercial space launch activity could also change the mix of aircraft in service, with associated impacts on aviation noise and emissions. The emissions from commercial space operations are expected to have a negative impact on both climate change and the ozone layer; however, the magnitude of the impacts is unknown at this time with the various fuel types currently used to launch vehicles.

Appendix A: Alternative Forecast Scenarios

Uncertainty exists in all industries, but especially in the commercial air travel industry. As volatility in the global environment has increased, the importance of scenarios for planning purposes has increased. In order to help stakeholders better prepare for the future, the FAA provides alternative scenarios to our baseline forecasts of airline traffic and capacity.

To create the baseline domestic forecast, economic assumptions from IHS Markit's 10-year and 30-year U.S. Macro Baselines were used. To develop the alternative scenarios, assumptions from IHS Markit's 30-year optimistic and pessimistic forecasts from their August 2022 *US Economy: The 30-Year Focus* were utilized. Inputs from these alternative scenarios were used to create "high" and "low" traffic, capacity, and yield forecasts.

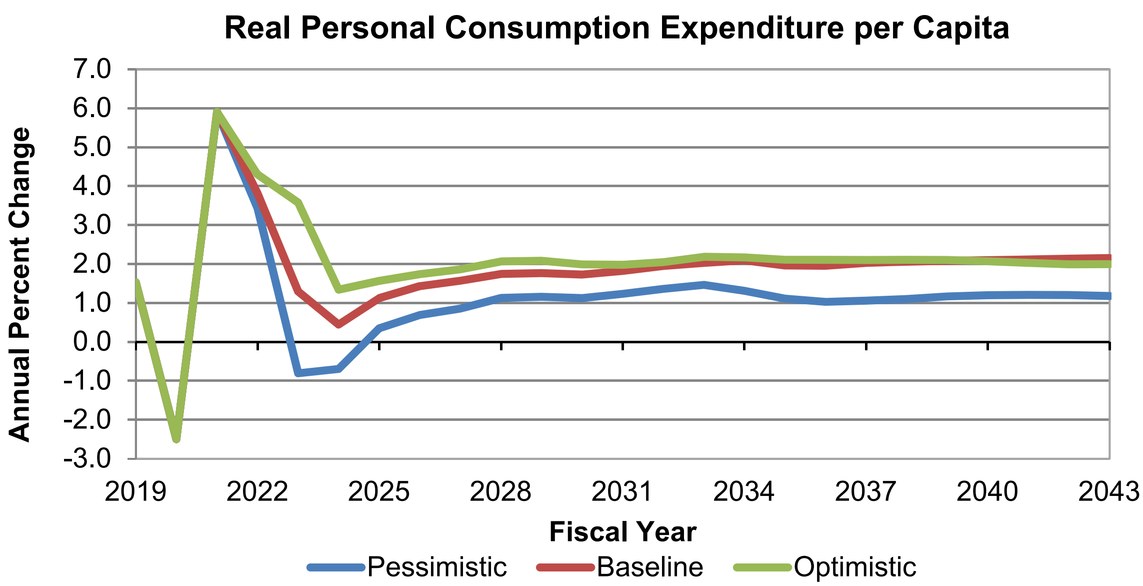
International passengers and traffic are primarily driven by country specific Gross Domestic Product (GDP) forecasts provided by IHS Markit. Thus, the alternative scenarios use inputs based on ratios derived from IHS Markit's Major Trading Partner and Other Important Trading Partners optimistic and pessimistic forecasts in order to create high and low cases.

Scenario Assumptions

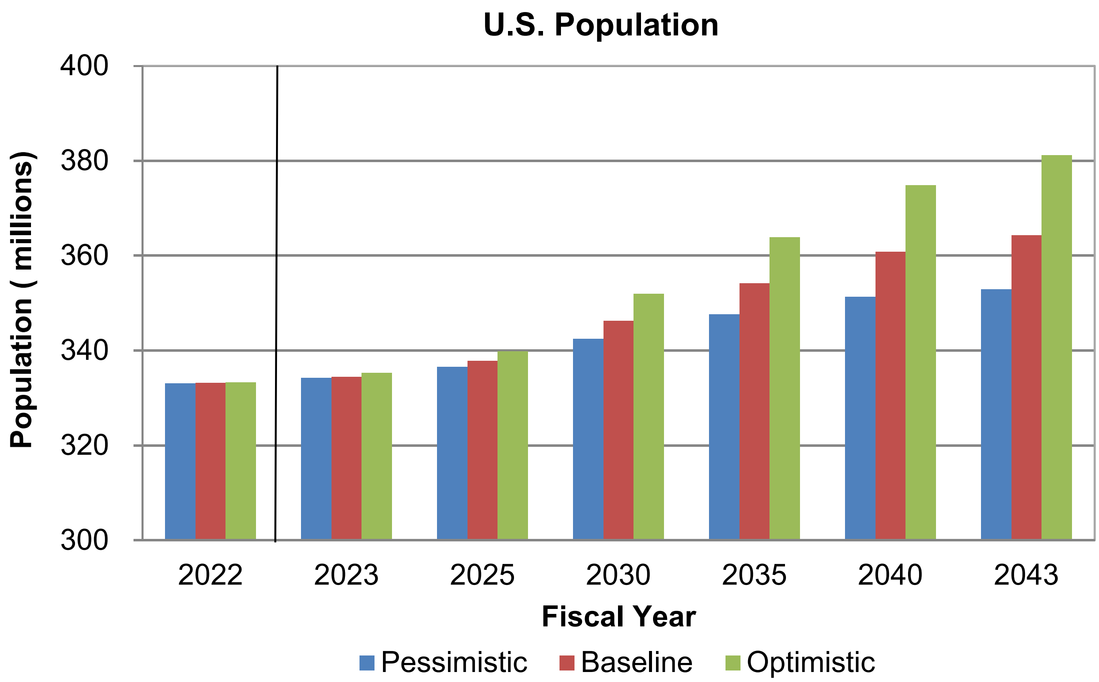
The FAA's domestic baseline forecast assumes a mild recession in the first half of 2023 followed by stronger activity that keeps growth positive for the full year. Following a pick-up in the few years immediately after, growth edges back to about trend for the remainder of the forecast. Efforts to bring inflation down slow GDP growth in the near term and raise the unemployment rate to about 5.5 percent by the end of 2023. Subsequent years see a gradual reduction in interest rates leading to a strengthening economy and lower unemployment. After the oil price surge in 2022, crude retreats as global economic activity, and energy demand, slows. Thereafter, oil price remains roughly flat, balanced by upward pressure from decreasing supply and downward from technological innovation.

The FAA's high case forecast uses IHS Markit's optimistic forecast. The optimistic scenario is characterized by a faster resolution to the Russia-Ukraine conflict resulting in lower energy prices, and GDP growth that remains positive throughout the forecast. Near-term differences include GDP growth of 1.2 percent in 2023 compared to 0.3 percent in the baseline, driven mainly by stronger consumer spending. Consumer spending rises 2.2 percent in 2023 and 1.3 percent in 2024, versus 1.3 percent and 1.1 percent in the base forecast. Stronger spending results from lower energy expenditures and increased confidence due to lessened political tensions. The unemployment rate rises but 2-3 tenths less than in the baseline.

Conversely, FAA's low case forecast uses IHS Markit's pessimistic scenario. In this forecast, the worse outcome is mainly due to a protracted Russia-Ukraine conflict which leads to higher energy prices and intensifies supply-chain disruptions. GDP growth in 2023 is -0.5 percent compared to 0.3 percent in the baseline. Over the forecast horizon, average GDP growth is six tenths slower than in the baseline. Contributing to slower GDP growth in this scenario, business capital investments and residential housing investments both grow more slowly than in the baseline, resulting in lower overall productivity growth. The combination of supply chain problems and consumer hesitancy (spending is about half the rate in the base case) causes businesses to scale back investments. Oil prices rise faster than the baseline throughout the forecast and are $85 per barrel higher by 2043. In the near term, the unemployment rate rises about 2 percentage points higher than the baseline.



Source: IHS Markit



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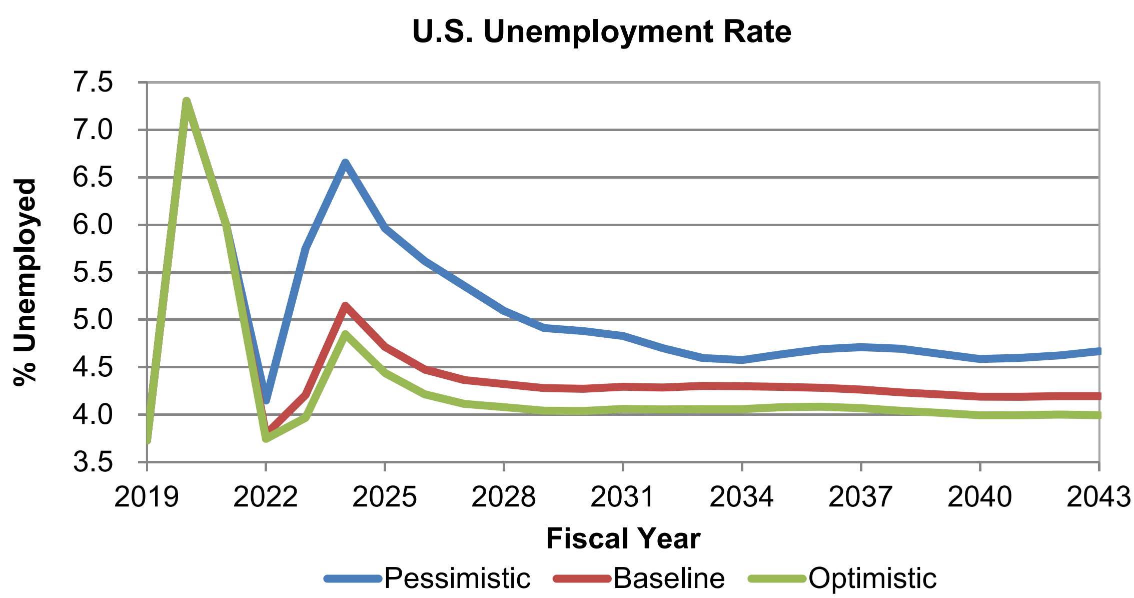

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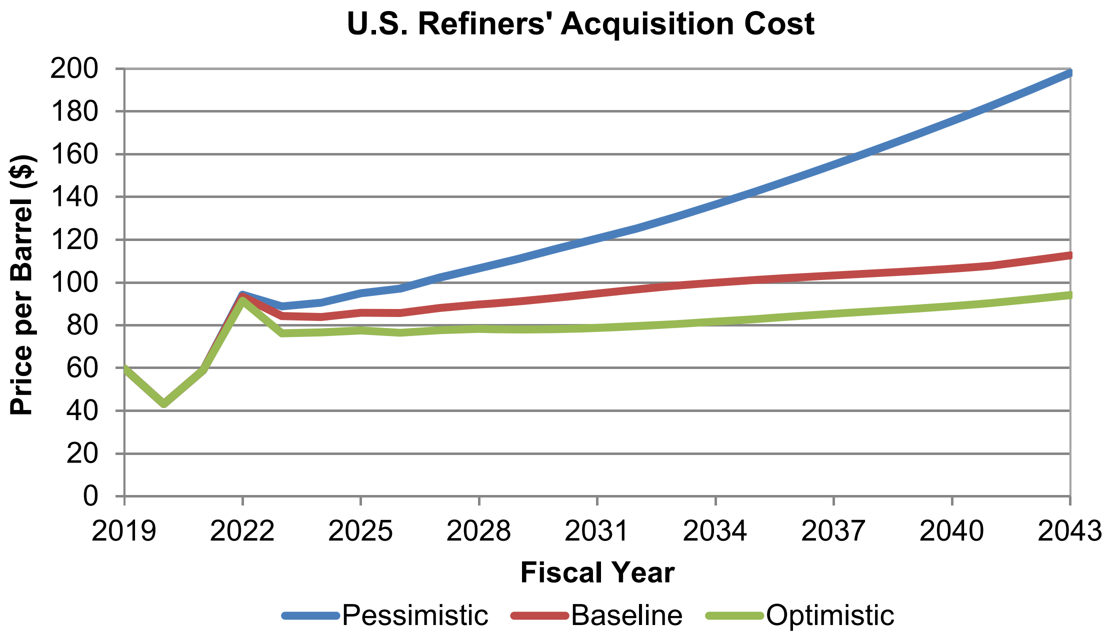
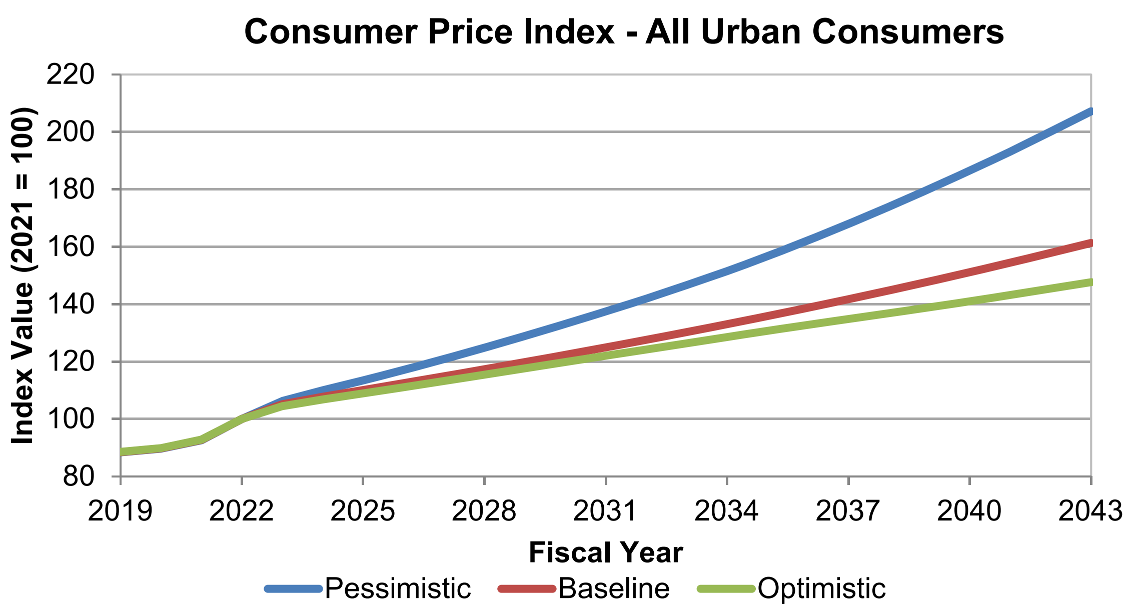


Source: IHS Markit

The price of energy is one of the drivers in the growth of consumer prices over the forecast period. In the optimistic case, slow growth of energy prices and import prices counteracts faster growth of other consumer goods prices causing the optimistic CPI to rise somewhat slower than the baseline. In the pessimistic case, energy prices, wages and import prices all rise more rapidly compared to the baseline.



Source: IHS Markit

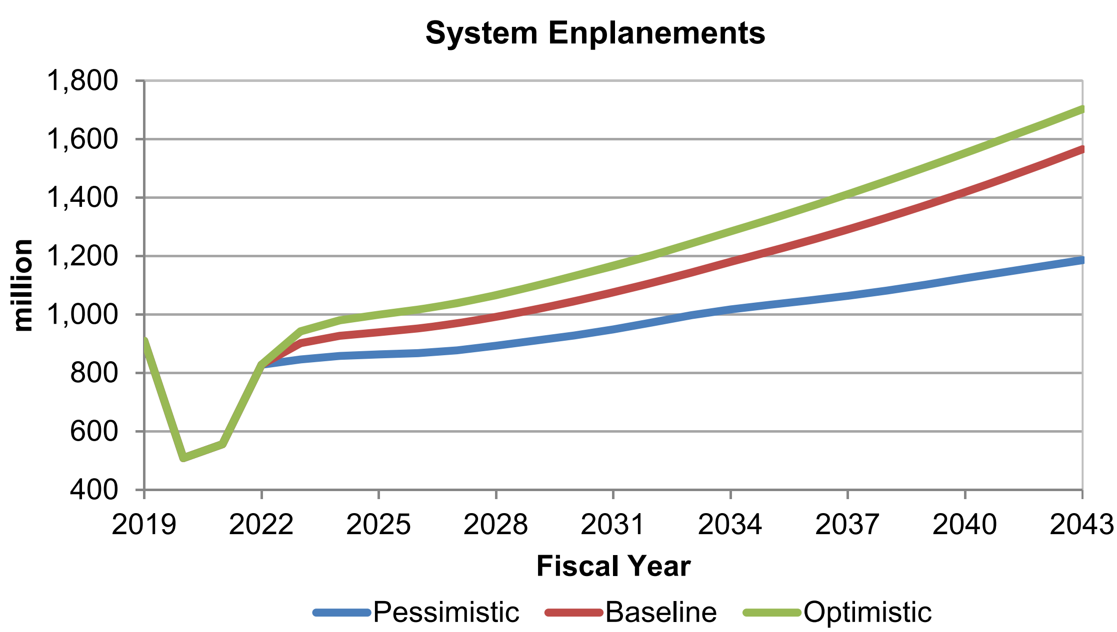
Alternative Forecasts

Enplanements

In the baseline forecast, system enplanements are forecast to grow at an average annual rate of 3.1 percent a year over the forecast horizon of 2023-2043 (with domestic and international passengers increasing at rates of 3.0 and 3.9 percent, respectively).

In the optimistic case, enplanements grow at a slightly quicker pace, averaging 3.5 percent per year (up 3.4 percent domestically and 4.3 percent internationally). This scenario is marked by a more favorable business environment and lower fuel prices which make the price of flying more affordable to business and leisure travelers. By the end of the forecast period in 2043, system passengers in the optimistic case are 9 percent above the baseline, totaling 1.7 billion, 137 million greater than in the baseline.

The pessimistic case is characterized by a period of weakened personal income growth and consumer confidence combined with high inflation, leading to higher interest rates, and curtailed investment and consumer spending. In this scenario, enplanements grow an average of 1.7 percent per year (domestic up 1.5 percent and international up 3.3 percent). In the pessimistic case, system passengers in 2043 are 24 percent below the baseline case, totaling 1.2 billion, or 379 million fewer than in the baseline.

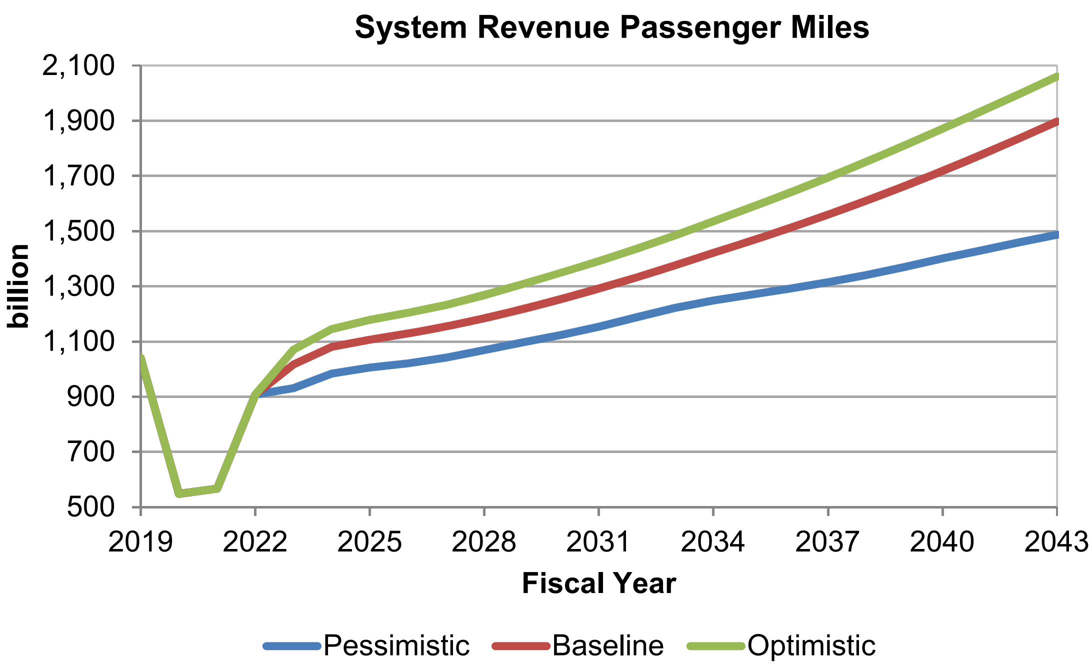


Revenue Passenger Miles

In the baseline forecast, system RPMs grow at an average annual rate of 3.6 percent a year over the forecast horizon (2023-2043), with domestic RPMs increasing 3.2 percent annually and international RPMs growing 4.6 percent annually.

In the optimistic case, the faster growing economy coupled with lower energy prices drives RPMs higher than the baseline, with growth averaging 4.0 percent per year (domestic and international RPMs up 3.6 and 5.0 percent, respectively).

In the pessimistic case, the combination of a slower growing economy and higher energy prices result in RPM growth averaging 2.4 percent annually with domestic markets growing 1.7 percent a year while international traffic grows 4.1 percent annually.

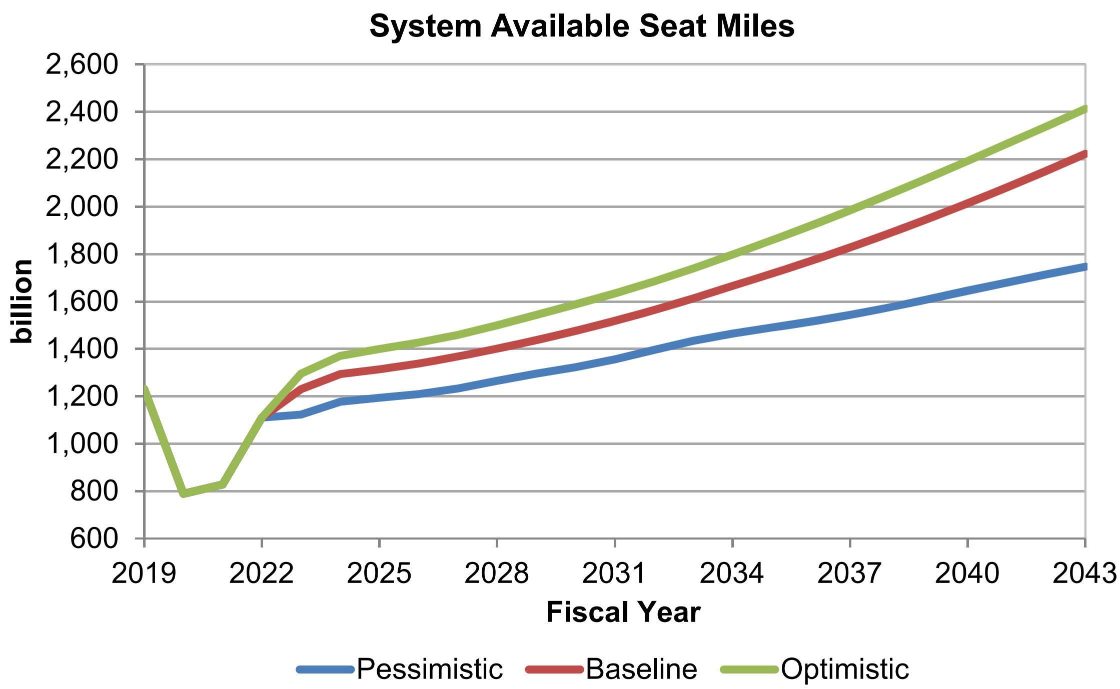


Available Seat Miles

In the base case, system capacity is forecast to increase an average of 3.4 percent annually over the forecast horizon with growth averaging 3.0 percent annually in domestic markets and 4.3 percent a year in international markets.

In the optimistic case, capacity grows somewhat faster than in the baseline forecast, averaging 3.8 percent annually system-wide (3.4 and 4.6 percent for domestic and international markets, respectively). Carriers increase capacity compared to the baseline forecast to accommodate increased travel demand brought about by a more favorable economic environment.

In the pessimistic case, demand for air travel is lower than in the baseline, thus system capacity grows at a slower pace of 2.2 percent annually (domestic growth of 1.5 percent annually and international up 3.7 percent annually).



Load Factor

System load factors over the 20-year forecast period are similar for all three forecast scenarios. System load factor rises from 81.8 percent in 2022 to 85.4 (optimistic), 85.1 (pessimistic), and 85.4 (baseline) percent in 2043.

In all three scenarios it is assumed that carriers will keep load factors on the high side by actively managing capacity (seats) to more precisely meet demand (passengers).

The domestic load factor increases over the forecast horizon from 83.5 percent to 86.7 percent in the baseline, optimistic and pessimistic scenarios.

The international load factor rises in the baseline from 76.6 percent to 82.3 percent; in the optimistic to 82.3 percent; and in the pessimistic to 82.2 percent. This reflects in part the relative growth in demand and capacity in the three (Atlantic, Latin, and Pacific) international regions under each scenario.

Yield

In the baseline forecast, nominal system yield increases 1.2 percent annually, rising from 15.38 cents in 2022 to 19.67 cents in 2043. In domestic markets, yield in the baseline forecast rises from 15.40 cents in 2022 to 19.32 cents in 2043. International yield rises from 15.30 cents in 2022 to 20.53 cents in 2043.

System yield rises in the optimistic case at a slower rate than in the baseline, up 0.8 percent annually to 18.17 cents in 2043. Domestic yield increases to 17.61 cents while international yield increases to 19.57 cents. The moderate growth in yield in both cases is due to advancements in technology, gains in productivity, and modestly rising fuel prices.

In the pessimistic case, nominal yields rise more rapidly than in the baseline, growing an average of 2.3 percent annually, reaching 24.58 cents by 2043 (25.22 cents domestically and 23.31 cents internationally). This scenario reflects higher general domestic inflation and markedly higher energy prices than in the baseline, forcing carriers to increase fares in order to cover the higher costs of fuel, labor, and capital.

TABLE A-1

FAA FORECAST ECONOMIC ASSUMPTIONS

FISCAL YEARS 2022-2043

		Historical	FORECAST					PERCENT AVERAGE ANNUAL GROWTH				
Variable	Scenario	2022E	2023	2028	2033	2038	2043	2022-23	2023-28	2023-33	2023-38	2023-43
Economic Assumptions												
Real Personal Consumption	Pessimistic	42,111	41,773	42,749	45,529	48,142	51,072	-0.8%	0.5%	0.9%	1.0%	1.0%
Expenditure per Capita	Baseline	42,266	42,814	45,584	49,978	55,230	61,329	1.3%	1.3%	1.6%	1.7%	1.8%
(2012 $)	Optimistic	42,462	43,982	47,884	53,012	58,869	65,115	3.6%	1.7%	1.9%	2.0%	2.0%
Refiners Acquisition Cost -	Pessimistic	94.3	88.9	106.7	130.7	161.7	198.0	-5.8%	3.7%	3.9%	4.1%	4.1%
Average - $ Per Barrel	Baseline	93.4	84.3	89.7	98.6	104.3	112.7	-9.8%	1.2%	1.6%	1.4%	1.5%
	Optimistic	91.5	76.2	78.2	80.6	86.5	94.1	-16.7%	0.5%	0.6%	0.8%	1.1%
Consumer Price Index	Pessimistic	2.88	3.06	3.59	4.22	5.00	5.96	6.2%	3.3%	3.3%	3.3%	3.4%
All Urban, 1982-84 = 1	Baseline	2.88	3.02	3.38	3.75	4.17	4.64	5.1%	2.2%	2.2%	2.2%	2.2%
	Optimistic	2.88	3.00	3.32	3.64	3.94	4.25	4.4%	2.0%	1.9%	1.8%	1.7%
Civilian Unemployment Rat(	Pessimistic	4.1	5.8	5.1	4.6	4.7	4.7	38.6%	-2.4%	-2.2%	-1.3%	-1.0%
(%)	Baseline	3.8	4.2	4.3	4.3	4.2	4.2	10.9%	0.5%	0.2%	0.0%	0.0%
	Optimistic	3.7	4.0	4.1	4.1	4.0	4.0	6.0%	0.6%	0.2%	0.1%	0.0%

Source: IHS Markit

TABLE A-2

FAA FORECAST OF AVIATION ACTIVITY*

FISCAL YEARS 2022-2043

		Historical	FORECAST					PERCENT AVERAGE ANNUAL GROWTH				
Variable	Scenario	2022E	2023	2028	2033	2038	2043	2022-23	2023-28	2023-33	2023-38	2023-43
System Aviation Activity												
Available Seat Miles	Pessimistic	1,110.4	1,123.6	1,265.7	1,434.3	1,575.2	1,747.1	1.2%	2.4%	2.5%	2.3%	2.2%
(BIL)	Baseline	1,110.4	1,230.8	1,401.4	1,613.2	1,888.4	2,223.3	10.8%	2.6%	2.7%	2.9%	3.0%
	Optimistic	1,110.4	1,295.9	1,500.1	1,739.5	2,052.3	2,413.3	16.7%	3.0%	3.0%	3.1%	3.2%
Revenue Passenger Miles	Pessimistic	907.9	931.2	1,069.7	1,222.6	1,341.3	1,487.6	2.6%	2.8%	2.8%	2.5%	2.4%
(BIL)	Baseline	907.9	1,017.4	1,184.4	1,376.8	1,610.8	1,897.9	12.1%	3.1%	3.1%	3.1%	3.2%
	Optimistic	907.9	1,070.5	1,268.3	1,485.3	1,751.6	2,060.8	17.9%	3.4%	3.3%	3.3%	3.3%
Enplanements	Pessimistic	828.4	846.3	893.3	997.8	1,082.4	1,186.4	2.2%	1.1%	1.7%	1.7%	1.7%
(MIL)	Baseline	828.4	902.3	992.0	1,144.3	1,332.2	1,565.8	8.9%	1.9%	2.4%	2.6%	2.8%
	Optimistic	828.4	942.6	1,066.4	1,243.7	1,457.5	1,703.1	13.8%	2.5%	2.8%	2.9%	3.0%
Psgr Carrier Miles Flown	Pessimistic	6,862.4	6,694.5	7,217.7	8,019.8	8,681.3	9,488.2	-2.4%	1.5%	1.8%	1.7%	1.8%
(MIL)	Baseline	6,862.4	7,255.7	8,002.8	9,089.0	10,515.8	12,247.9	5.7%	2.0%	2.3%	2.5%	2.7%
	Optimistic	6,862.4	7,616.5	8,583.0	9,832.4	11,460.9	13,308.9	11.0%	2.4%	2.6%	2.8%	2.8%
Psgr Carrier Departures	Pessimistic	8,011.0	7,637.1	7,676.0	8,250.6	8,738.1	9,338.9	-4.7%	0.1%	0.8%	0.9%	1.0%
(000s)	Baseline	8,011.0	8,096.1	8,502.6	9,448.3	10,727.6	12,293.1	1.1%	1.0%	1.6%	1.9%	2.1%
	Optimistic	8,011.0	8,440.1	9,133.4	10,253.2	11,727.9	13,366.0	5.4%	1.6%	2.0%	2.2%	2.3%
Nominal Passenger Yield	Pessimistic	15.38	15.67	17.29	19.03	21.59	24.58	1.9%	2.0%	2.0%	2.2%	2.3%
(cents)	Baseline	15.38	15.50	16.52	17.51	18.54	19.67	0.7%	1.3%	1.2%	1.2%	1.2%
	Optimistic	15.38	15.35	16.29	17.06	17.63	18.17	-0.2%	1.2%	1.1%	0.9%	0.8%

* Includes domestic and international activity.

TABLE A-3

FAA FORECAST OF DOMESTIC AVIATION ACTIVITY

FISCAL YEARS 2022-2043

		Historical	FORECAST					PERCENT AVERAGE ANNUAL GROWTH				
Variable	Scenario	2022E	2023	2028	2033	2038	2043	2022-23	2023-28	2023-33	2023-38	2023-43
Domestic Aviation Activity												
Available Seat Miles	Pessimistic	832.8	848.2	863.9	950.9	1,039.3	1,146.3	1.8%	0.4%	1.1%	1.4%	1.5%
(BIL)	Baseline	832.8	888.3	961.7	1,106.2	1,304.3	1,554.5	6.7%	1.6%	2.2%	2.6%	2.8%
	Optimistic	832.8	922.8	1,035.9	1,208.2	1,432.6	1,692.4	10.8%	2.3%	2.7%	3.0%	3.1%
Revenue Passenger Miles	Pessimistic	695.2	716.2	740.0	825.0	900.7	993.8	3.0%	0.7%	1.4%	1.5%	1.7%
(BIL)	Baseline	695.2	750.1	823.7	959.8	1,130.3	1,347.6	7.9%	1.9%	2.5%	2.8%	3.0%
	Optimistic	695.2	779.3	887.4	1,048.3	1,241.6	1,467.2	12.1%	2.6%	3.0%	3.2%	3.2%
Enplanements	Pessimistic	737.8	764.4	779.3	857.5	923.8	1,005.9	3.6%	0.4%	1.2%	1.3%	1.4%
(MIL)	Baseline	737.8	800.5	867.4	997.5	1,159.2	1,363.9	8.5%	1.6%	2.2%	2.5%	2.7%
	Optimistic	737.8	831.7	934.6	1,089.6	1273.5	1,485.1	12.7%	2.4%	2.7%	2.9%	2.9%
Psgr Carrier Miles Flown	Pessimistic	5,573.4	5,451.9	5,449.7	5,897.2	6,339.3	6,877.9	-2.2%	0.0%	0.8%	1.0%	1.2%
(MIL)	Baseline	5,573.4	5,710.6	6,068.8	6,864.4	7,962.1	9,336.9	2.5%	1.2%	1.9%	2.2%	2.5%
	Optimistic	5,573.4	5,933.5	6,539.4	7,499.9	8,749.3	10,168.7	6.5%	2.0%	2.4%	2.6%	2.7%
Psgr Carrier Departures	Pessimistic	7,369.7	7,070.7	6,914.4	7,317.5	7,691.2	8,156.1	-4.1%	-0.4%	0.3%	0.6%	0.7%
(000s)	Baseline	7,369.7	7,391.9	7,670.4	8,472.8	9,584.9	10,968.0	0.3%	0.7%	1.4%	1.7%	2.0%
	Optimistic	7,369.7	7,673.0	8,251.5	9,228.3	10,511.6	11,934.4	4.1%	1.5%	1.9%	2.1%	2.2%
Nominal Passenger Yield	Pessimistic	15.40	15.65	17.67	19.75	22.28	25.22	1.6%	2.5%	2.4%	2.4%	2.4%
(cents)	Baseline	15.40	15.46	16.52	17.40	18.30	19.32	0.3%	1.3%	1.2%	1.1%	1.1%
	Optimistic	15.40	15.29	16.16	16.74	17.19	17.61	-0.7%	1.1%	0.9%	0.8%	0.7%

TABLE A-4

FAA FORECAST OF INTERNATIONAL AVIATION ACTIVITY*

FISCAL YEARS 2022-2043

		Historical	FORECAST					PERCENT AVERAGE ANNUAL GROWTH				
Variable	Scenario	2022E	2023	2028	2033	2038	2043	2022-23	2023-28	2023-33	2023-38	2023-43
International Aviation Activity												
Available Seat Miles	Pessimistic	277.7	275.5	401.8	483.4	536.0	600.8	-0.8%	7.8%	5.8%	4.5%	4.0%
(BIL)	Baseline	277.7	342.5	439.7	507.0	584.1	668.8	23.4%	5.1%	4.0%	3.6%	3.4%
	Optimistic	277.7	373.1	464.1	531.3	619.7	720.9	34.4%	4.5%	3.6%	3.4%	3.3%
Revenue Passenger Miles	Pessimistic	212.7	215.0	329.6	397.6	440.7	493.9	1.1%	8.9%	6.3%	4.9%	4.2%
(BIL)	Baseline	212.7	267.3	360.7	417.0	480.5	550.3	25.7%	6.2%	4.5%	4.0%	3.7%
	Optimistic	212.7	291.2	380.8	437.0	510.0	593.6	36.9%	5.5%	4.1%	3.8%	3.6%
Enplanements	Pessimistic	90.6	81.9	114.0	140.3	158.6	180.6	-9.6%	6.8%	5.5%	4.5%	4.0%
(MIL)	Baseline	90.6	101.8	124.6	146.8	173.0	201.9	12.4%	4.1%	3.7%	3.6%	3.5%
	Optimistic	90.6	110.9	131.9	154.1	184.0	218.0	22.4%	3.5%	3.3%	3.4%	3.4%
Psgr Carrier Miles Flown	Pessimistic	1,288.9	1,242.6	1,768.0	2,122.5	2,342.0	2,610.3	-3.6%	7.3%	5.5%	4.3%	3.8%
(MIL)	Baseline	1,288.9	1,545.1	1,934.0	2,224.6	2,553.7	2,911.0	19.9%	4.6%	3.7%	3.4%	3.2%
	Optimistic	1,288.9	1,683.0	2,043.6	2,332.5	2,711.7	3,140.2	30.6%	4.0%	3.3%	3.2%	3.2%
Psgr Carrier Departures	Pessimistic	641.3	566.4	761.6	933.1	1,046.9	1,182.8	-11.7%	6.1%	5.1%	4.2%	3.8%
(000s)	Baseline	641.3	704.3	832.2	975.5	1,142.7	1,325.1	9.8%	3.4%	3.3%	3.3%	3.2%
	Optimistic	641.3	767.1	882.0	1,024.9	1,216.4	1,431.7	19.6%	2.8%	2.9%	3.1%	3.2%
Nominal Passenger Yield	Pessimistic	15.30	15.72	16.43	17.54	20.18	23.31	2.8%	0.9%	1.1%	1.7%	2.0%
(cents)	Baseline	15.30	15.60	16.53	17.77	19.08	20.53	2.0%	1.2%	1.3%	1.4%	1.4%
	Optimistic	15.30	15.50	16.58	17.83	18.71	19.57	1.3%	1.4%	1.4%	1.3%	1.2%

*Includes mainline and regional carriers.

Appendix B: Forecast Tables

TABLE 1

U.S. SHORT-TERM ECONOMIC FORECASTS

ECONOMIC VARIABLE	FISCAL YEAR 2022				FISCAL YEAR 2023				FISCAL YEAR 2024			
	1ST. QTR.	2ND. QTR.	3RD QTR.	4TH. QTR.	1ST. QTR.	2ND. QTR.	3RD QTR.	4TH. QTR.	1ST. QTR.	2ND. QTR.	3RD QTR.	4TH. QTR.
Real Personal Consumption												
Expenditure per Capita												
(2012 $)	42,056	42,168	42,348	42,492	42,792	42,824	42,809	42,832	42,882	42,946	43,038	43,150
Year over year change	-2.6%	1.9%	16.1%	6.9%	7.1%	4.9%	2.5%	2.7%	2.0%	1.8%	1.8%	1.8%
Refiners' Acquisition Cost - Average												
(Dollars per barrel)	76.43	92.42	109.78	95.07	87.42	86.93	79.98	82.82	86.10	84.46	81.33	83.29
Year over year change	-27.5%	21.1%	148.6%	74.2%	91.2%	30.4%	9.0%	3.6%	-10.6%	-10.3%	-5.2%	-10.6%
Consumer Price Index												
(1982-84 = 1)	2.78	2.85	2.92	2.96	2.99	3.02	3.03	3.06	3.08	3.09	3.10	3.12
Year over year change	1.2%	1.9%	4.8%	5.3%	5.8%	5.2%	3.7%	2.6%	1.9%	2.1%	2.1%	2.1%

Source: IHS Markit

TABLE 2

U.S. LONG-TERM ECONOMIC FORECASTS

FISCAL YEAR	REAL GROSS DOMESTIC PRODUCT (Billions 2012 $)	REAL PERSONAL CONSUMPTION EXPENDITURE PER CAPITA (2012 $)	CONSUMER PRICE INDEX (1982-84=1.00)	REFINERS' ACQUISITION COST AVERAGE (Dollars per barrel)
Historical				
2010	15,542	34,403	2.17	74.61
2015	17,310	36,721	2.37	56.69
2019	18,916	39,426	2.54	59.77
2020	18,582	38,441	2.58	43.15
2021	19,339	40,712	2.67	58.91
2022E	19,966	42,266	2.88	93.42
Forecast				
2023	20,024	42,814	3.02	84.29
2028	21,805	45,584	3.38	89.68
2033	23,740	49,978	3.75	98.57
2038	26,083	55,230	4.17	104.30
2043	28,822	61,329	4.64	112.70
Avg Annual Growth				
2010-22	2.1%	1.7%	2.4%	1.9%
2022-23	0.3%	1.3%	5.1%	-9.8%
2023-33	1.7%	1.6%	2.2%	1.6%
2023-43	1.8%	1.8%	2.2%	1.5%

Source: IHS Markit

TABLE 3

INTERNATIONAL GDP FORECASTS BY TRAVEL REGION

	GROSS DOMESTIC PRODUCT (In Billions of 2015 U.S. Dollars)				
CALENDAR YEAR	CANADA	EUROPE / AFRICA / MIDDLE EAST	LATIN AMERICA / CARIBBEAN / MEXICO	JAPAN / PACIFIC BASIN / CHINA / OTHER ASIA / AUSTRALIA / NEW ZEALAND	WORLD
Historical					
2010	1,400	21,233	4,624	18,977	64,628
2015	1,557	23,305	5,187	24,465	74,635
2019	1,696	25,464	5,399	29,468	84,090
2020	1,610	24,063	5,042	29,215	81,448
2021	1,691	25,421	5,386	31,056	86,310
2022E	1,751	26,402	5,575	32,033	88,826
Forecast					
2023	1,764	26,560	5,655	33,226	90,283
2028	1,923	29,329	6,509	40,863	104,061
2033	2,093	32,060	7,551	48,965	118,540
2038	2,282	34,930	8,720	57,906	134,593
2043	2,488	37,955	10,022	67,550	152,024
Avg Annual Growth					
2010-22	1.9%	1.8%	1.6%	4.5%	2.7%
2022-23	0.7%	0.6%	1.4%	3.7%	1.6%
2023-33	1.7%	1.9%	2.9%	4.0%	2.8%
2023-43	1.7%	1.8%	2.9%	3.6%	2.6%

Source: IHS Markit website, GDP Components Tables (Interim Forecast, Monthly)

TABLE 4

INTERNATIONAL GDP FORECASTS – SELECTED AREAS/COUNTRIES

	GROSS DOMESTIC PRODUCT (In Billions of 2015 U.S. Dollars)				
CALENDAR YEAR	NORTH AMERICA (USMCA)	EUROZONE	UNITED KINGDOM	JAPAN	CHINA
Historical					
2010	18,794	11,195	2,662	4,220	7,490
2015	20,934	11,668	2,936	4,446	10,961
2019	22,877	12,626	3,176	4,565	14,166
2020	22,137	11,832	2,825	4,367	14,480
2021	23,426	12,459	3,038	4,464	15,654
2022E	23,914	12,871	3,172	4,518	16,096
Forecast					
2023	24,004	12,851	3,148	4,571	16,831
2028	26,259	13,884	3,355	4,798	21,468
2033	28,648	14,769	3,600	4,993	26,300
2038	31,547	15,646	3,865	5,172	31,629
2043	34,645	16,545	4,160	5,332	37,079
Avg Annual Growth					
2010-22	2.0%	1.2%	1.5%	0.6%	6.6%
2022-23	0.4%	-0.2%	-0.8%	1.2%	4.6%
2023-33	1.8%	1.4%	1.3%	0.9%	4.6%
2023-43	1.9%	1.3%	1.4%	0.8%	4.0%

Source: IHS Markit website, GDP Components Tables (Interim Forecast, Monthly)

TABLE 5

U.S. COMMERCIAL AIR CARRIERS[1]

TOTAL SCHEDULED U.S. PASSENGER TRAFFIC

	REVENUE PASSENGER ENPLANEMENTS (Millions)			REVENUE PASSENGER MILES (Billions)		
FISCAL YEAR	DOMESTIC	INTERNATIONAL	TOTAL	DOMESTIC	INTERNATIONAL	TOTAL
Historical						
2010	631	77	709	553	231	784
2015	692	90	782	625	261	886
2019	806	104	910	748	292	1,040
2020	461	49	509	420	129	548
2021	507	49	556	476	92	567
2022E	738	91	828	695	213	908
Forecast						
2023	800	102	902	750	267	1,017
2028	867	125	992	824	361	1,184
2033	997	147	1,144	960	417	1,377
2038	1,159	173	1,332	1,130	481	1,611
2043	1,364	202	1,566	1,348	550	1,898
Avg Annual Growth						
2010-22	1.3%	1.3%	1.3%	1.9%	-0.7%	1.2%
2022-23	8.5%	12.4%	8.9%	7.9%	25.7%	12.1%
2023-33	2.2%	3.7%	2.4%	2.5%	4.5%	3.1%
2023-43	2.7%	3.5%	2.8%	3.0%	3.7%	3.2%

Source: Forms 41 and 298-C, U.S. Department of Transportation.

[1]Sum of U.S. Mainline and Regional Air Carriers.

TABLE 6

U.S. COMMERCIAL AIR CARRIERS[1]

SCHEDULED PASSENGER CAPACITY, TRAFFIC, AND LOAD FACTORS

	DOMESTIC			INTERNATIONAL			SYSTEM		
FISCAL YEAR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR
Historical									
2010	677	553	81.7	281	231	82.1	958	784	81.8
2015	740	625	84.6	323	261	80.7	1,063	886	83.4
2019	879	748	85.2	352	292	82.9	1,231	1,040	84.5
2020	612	420	68.6	178	129	72.3	789	548	69.5
2021	657	476	72.4	171	92	53.5	828	567	68.5
2022E	833	695	83.5	278	213	76.6	1,110	908	81.8
Forecast									
2023	888	750	84.4	343	267	78.0	1,231	1,017	82.7
2028	962	824	85.7	440	361	82.0	1,401	1,184	84.5
2033	1,106	960	86.8	507	417	82.2	1,613	1,377	85.3
2038	1,304	1,130	86.7	584	481	82.3	1,888	1,611	85.3
2043	1,554	1,348	86.7	669	550	82.3	2,223	1,898	85.4
Avg Annual Growth									
2010-22	1.7%	1.9%		-0.1%	-0.7%		1.2%	1.2%	
2022-23	6.7%	7.9%		23.4%	25.7%		10.8%	12.1%	
2023-33	2.2%	2.5%		4.0%	4.5%		2.7%	3.1%	
2023-43	2.8%	3.0%		3.4%	3.7%		3.0%	3.2%	

Source: Forms 41 and 298-C, U.S. Department of Transportation.

[1]Sum of U.S. Mainline and Regional Air Carriers.

TABLE 7

U.S. COMMERCIAL AIR CARRIERS[1]

TOTAL SCHEDULED U.S. INTERNATIONAL PASSENGER TRAFFIC

	REVENUE PASSENGER ENPLANEMENTS				REVENUE PASSENGER MILES			
FISCAL YEAR	ATLANTIC (Mil)	LATIN AMERICA (Mil)	PACIFIC (Mil)	TOTAL INTERNATIONAL (Mil)	ATLANTIC (Bil)	LATIN AMERICA (Bil)	PACIFIC (Bil)	TOTAL INTERNATIONAL (Bil)
Historical								
2010	25	40	13	77	109	63	59	231
2015	25	52	14	90	107	83	71	261
2019	28	63	13	104	121	96	75	292
2020	11	32	6	49	48	49	31	129
2021	6	43	1	49	27	60	4	92
2022E	23	66	3	91	100	98	15	213
Forecast								
2023	29	66	7	102	128	98	41	267
2028	34	77	13	125	158	121	82	361
2033	37	95	15	147	173	150	94	417
2038	41	115	17	173	191	184	106	481
2043	45	139	18	202	209	223	118	550
Avg Annual Growth								
2010-22	-0.7%	4.2%	-12.6%	1.3%	-0.7%	3.7%	-10.8%	-0.7%
2022-23	29.1%	0.5%	167.6%	12.4%	27.8%	0.8%	173.8%	25.7%
2023-33	2.5%	3.7%	7.9%	3.7%	3.1%	4.3%	8.6%	4.5%
2023-43	2.2%	3.8%	5.1%	3.5%	2.5%	4.2%	5.4%	3.7%

Source: Forms 41 and 298-C, U.S. Department of Transportation.

[1]Sum of U.S. Mainline and Regional Air Carriers.

TABLE 8

U.S. AND FOREIGN FLAG CARRIERS

TOTAL PASSENGER TRAFFIC TO/FROM THE UNITED STATES

	TOTAL PASSENGERS BY WORLD TRAVEL AREA (Millions)				
CALENDAR YEAR	ATLANTIC	LATIN AMERICA	PACIFIC	U.S./CANADA TRANSBORDER	TOTAL
Historical					
2010	56	53	27	22	158
2015	70	75	36	27	207
2019	89	89	44	32	253
2020	17	33	9	7	67
2021	24	66	4	5	99
2022E	71	88	15	21	195
Forecast					
2023	92	95	23	31	242
2028	111	111	44	40	305
2033	128	132	50	45	355
2038	146	159	58	52	415
2043	166	191	66	59	482
Avg Annual Growth					
2010-22	2.1%	4.3%	-4.6%	-0.4%	1.8%
2022-23	29.5%	8.0%	49.1%	50.5%	23.6%
2023-33	3.3%	3.4%	8.2%	3.8%	3.9%
2023-43	3.0%	3.6%	5.5%	3.2%	3.5%

Source: US Customs & Border Protection data processed and released by Department of Commerce; data also received from Transport Canada.

TABLE 9

U.S. COMMERCIAL AIR CARRIERS' FORECAST ASSUMPTIONS[1]

SEATS PER AIRCRAFT MILE AND PASSENGER TRIP LENGTH

	AVERAGE SEATS PER AIRCRAFT MILE			AVERAGE PASSENGER TRIP LENGTH		
FISCAL YEAR	DOMESTIC (Seats/Mile)	INTERNATIONAL (Seats/Mile)	SYSTEM (Seats/Mile)	DOMESTIC (Miles)	INTERNATIONAL (Miles)	SYSTEM (Miles)
Historical						
2010	122.2	216.4	140.1	875.7	2,988.0	1,106.1
2015	132.1	215.1	149.7	904.1	2,892.6	1,133.5
2019	141.9	221.4	158.2	928.5	2,813.9	1,143.5
2020	141.6	217.2	153.6	911.5	2,648.0	1,077.1
2021	145.2	198.6	153.7	938.0	1,859.6	1,019.6
2022E	149.4	215.4	161.8	942.3	2,347.4	1,096.0
Forecast						
2023	155.6	221.7	169.6	937.0	2,625.5	1,127.6
2028	158.5	227.3	175.1	949.6	2,895.4	1,194.0
2033	161.2	227.9	177.5	962.2	2,840.1	1,203.2
2038	163.8	228.7	179.6	975.0	2,777.4	1,209.1
2043	166.5	229.7	181.5	988.0	2,725.1	1,212.0
Avg Annual Growth						
2010-22	1.7%	0.0%	1.2%	0.6%	-2.0%	-0.1%
2022-23	4.1%	2.9%	4.8%	-0.6%	11.8%	2.9%
2023-33	0.4%	0.3%	0.5%	0.3%	0.8%	0.7%
2023-43	0.3%	0.2%	0.3%	0.3%	0.2%	0.4%

Source: Forms 41 and 298-C, U.S. Department of Transportation.

[1]Sum of U.S. Mainline and Regional Air Carriers.

TABLE 10

U. S. MAINLINE AIR CARRIERS

SCHEDULED PASSENGER TRAFFIC

	REVENUE PASSENGER ENPLANEMENTS (Millions)			REVENUE PASSENGER MILES (Billions)		
FISCAL YEAR	DOMESTIC	INTERNATIONAL	SYSTEM	DOMESTIC	INTERNATIONAL	SYSTEM
Historical						
2010	473	75	548	480	230	710
2015	543	87	630	556	259	815
2019	654	100	754	674	290	963
2020	368	47	415	374	127	502
2021	402	47	449	422	90	512
2022E	612	89	700	633	211	845
Forecast						
2023	649	99	748	675	266	941
2028	703	122	825	741	359	1,100
2033	809	144	953	864	415	1,279
2038	940	169	1,110	1,017	478	1,495
2043	1,106	198	1,304	1,213	547	1,760
Avg Annual Growth						
2010-22	2.2%	1.4%	2.1%	2.3%	-0.7%	1.5%
2022-23	6.1%	12.2%	6.9%	6.6%	25.7%	11.4%
2023-33	2.2%	3.8%	2.4%	2.5%	4.6%	3.1%
2023-43	2.7%	3.5%	2.8%	3.0%	3.7%	3.2%

Source: Form 41, U.S. Department of Transportation.

TABLE 11

U.S. MAINLINE AIR CARRIERS

SCHEDULED PASSENGER CAPACITY, TRAFFIC, AND LOAD FACTORS

	DOMESTIC			INTERNATIONAL			SYSTEM		
FISCAL YEAR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR
Historical									
2010	581	480	82.7	279	230	82.2	860	710	82.5
2015	653	556	85.1	321	259	80.8	973	815	83.7
2019	785	674	85.8	349	290	83.0	1,134	963	85.0
2020	542	374	69.0	176	127	72.4	718	502	69.8
2021	581	422	72.6	169	90	53.4	751	512	68.2
2022E	755	633	83.9	276	211	76.6	1,031	845	82.0
Forecast									
2023	794	675	85.1	340	266	78.1	1,134	941	83.0
2028	859	741	86.3	437	359	82.1	1,296	1,100	84.9
2033	988	864	87.4	504	415	82.3	1,492	1,279	85.7
2038	1,165	1,017	87.3	581	478	82.3	1,746	1,495	85.6
2043	1,389	1,213	87.3	665	547	82.3	2,054	1,760	85.7
Avg Annual Growth									
2010-22	2.2%	2.3%		-0.1%	-0.7%		1.5%	1.5%	
2022-23	5.1%	6.6%		23.4%	25.7%		10.0%	11.4%	
2023-33	2.2%	2.5%		4.0%	4.6%		2.8%	3.1%	
2023-43	2.8%	3.0%		3.4%	3.7%		3.0%	3.2%	

Source: Form 41, U.S. Department of Transportation.

TABLE 12

U.S. MAINLINE AIR CARRIERS

SCHEDULED INTERNATIONAL PASSENGER ENPLANEMENTS

	REVENUE PASSENGER ENPLANEMENTS (MIL)			
FISCAL YEAR	ATLANTIC	LATIN AMERICA	PACIFIC	TOTAL
Historical				
2010	24.5	37.2	12.9	74.6
2015	24.6	48.6	14.0	87.2
2019	27.9	59.2	13.2	100.2
2020	10.8	30.3	5.6	46.7
2021	5.7	40.9	0.8	47.4
2022E	22.6	63.4	2.6	88.5
Forecast				
2023	29.1	63.3	6.9	99.3
2028	34.5	74.3	13.1	121.9
2033	37.4	91.6	14.7	143.7
2038	41.0	111.9	16.5	169.4
2043	44.9	134.3	18.5	197.7
Avg Annual Growth				
2010-22	-0.7%	4.5%	-12.6%	1.4%
2022-23	29.1%	-0.1%	167.6%	12.2%
2023-33	2.5%	3.8%	7.9%	3.8%
2023-43	2.2%	3.8%	5.1%	3.5%

Source: Form 41, U.S. Department of Transportation.

TABLE 13

U.S. MAINLINE AIR CARRIERS

SCHEDULED PASSENGER CAPACITY, TRAFFIC, AND LOAD FACTORS BY INTERNATIONAL TRAVEL REGIONS

	ATLANTIC			LATIN AMERICA			PACIFIC			INTERNATIONAL		
FISCAL YEAR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR	ASMs (BIL)	RPMs (BIL)	% LOAD FACTOR
Historical												
2010	131	109	82.9	78	62	79.2	70	59	84.1	279	230	82.2
2015	133	107	80.0	101	81	80.3	86	71	82.5	321	259	80.8
2019	146	121	82.9	112	94	83.5	91	75	82.6	349	290	83.0
2020	69	48	69.3	63	48	76.2	44	31	71.8	176	127	72.4
2021	57	27	47.8	92	59	63.5	20	4	22.4	169	90	53.4
2022E	128	100	78.1	121	96	79.6	27	15	56.3	276	211	76.6
Forecast												
2023	160	128	80.0	121	97	80.0	59	41	69.0	340	266	78.1
2028	193	158	81.8	144	119	82.8	101	82	81.6	437	359	82.1
2033	211	173	81.8	179	148	82.8	114	94	82.4	504	415	82.3
2038	233	191	81.8	220	182	82.8	128	106	82.4	581	478	82.3
2043	256	209	81.8	265	220	82.8	143	118	82.4	665	547	82.3
Avg Annual Growth												
2010-22	-0.2%	-0.7%		3.7%	3.8%		-7.8%	-10.8%		-0.1%	-0.7%	
2022-23	24.8%	27.8%		-0.1%	0.5%		123.2%	173.8%		23.4%	25.7%	
2023-33	2.8%	3.1%		4.0%	4.4%		6.7%	8.6%		4.0%	4.6%	
2023-43	2.4%	2.5%		4.0%	4.2%		4.5%	5.4%		3.4%	3.7%	

Source: Form 41, U.S. Department of Transportation.

TABLE 14

U.S. MAINLINE AIR CARRIER FORECAST ASSUMPTIONS

SEATS PER AIRCRAFT MILE

		INTERNATIONAL				
FISCAL YEAR	DOMESTIC (Seats/Mile)	ATLANTIC (Seats/Mile)	LATIN AMERICA (Seats/Mile)	PACIFIC (Seats/Mile)	TOTAL (Seats/Mile)	SYSTEM (Seats/Mile)
Historical						
2010	152.0	231.7	171.7	287.2	220.9	169.2
2015	157.7	237.0	173.9	272.1	219.5	173.8
2019	166.0	251.6	177.9	269.9	225.6	180.7
2020	166.7	256.2	178.5	256.5	221.8	177.5
2021	171.7	255.4	178.8	205.8	202.4	177.8
2022E	171.1	260.5	180.3	265.8	218.3	181.6
Forecast						
2023	182.0	257.9	181.4	261.3	224.7	193.0
2028	185.4	260.4	183.9	265.4	230.0	198.3
2033	188.5	262.8	186.4	269.0	230.5	200.9
2038	191.6	265.3	188.9	272.7	231.3	203.2
2043	194.8	267.8	191.4	276.4	232.4	205.5
Avg Annual Growth						
2010-22	1.0%	1.0%	0.4%	-0.6%	-0.1%	0.6%
2022-23	6.3%	-1.0%	0.6%	-1.7%	2.9%	6.2%
2023-33	0.4%	0.2%	0.3%	0.3%	0.3%	0.4%
2023-43	0.3%	0.2%	0.3%	0.3%	0.2%	0.3%

Source: Form 41, U.S. Department of Transportation.

TABLE 15

U.S. MAINLINE AIR CARRIER FORECAST ASSUMPTIONS

AVERAGE PASSENGER TRIP LENGTH

		INTERNATIONAL				
FISCAL YEAR	DOMESTIC (Miles)	ATLANTIC (Miles)	LATIN AMERICA (Miles)	PACIFIC (Miles)	TOTAL (Miles)	SYSTEM (Miles)
Historical						
2010	1,015	4,433	1,660	4,587	3,077	1,296
2015	1,023	4,336	1,669	5,080	2,969	1,292
2019	1,030	4,330	1,582	5,709	2,890	1,278
2020	1,016	4,442	1,577	5,634	2,725	1,209
2021	1,050	4,756	1,434	5,809	1,906	1,141
2022E	1,036	4,438	1,519	5,835	2,388	1,207
Forecast						
2023	1,040	4,396	1,528	5,970	2,675	1,257
2028	1,054	4,571	1,601	6,276	2,945	1,333
2033	1,068	4,622	1,619	6,373	2,887	1,342
2038	1,082	4,645	1,627	6,392	2,822	1,348
2043	1,097	4,668	1,635	6,399	2,769	1,350
Avg Annual Growth						
2010-22	0.2%	0.0%	-0.7%	2.0%	-2.1%	-0.6%
2022-23	0.4%	-1.0%	0.6%	2.3%	12.1%	4.2%
2023-33	0.3%	0.5%	0.6%	0.7%	0.8%	0.7%
2023-43	0.3%	0.3%	0.3%	0.3%	0.2%	0.4%

Source: Form 41, U.S. Department of Transportation.

TABLE 16

U.S. MAINLINE AIR CARRIER FORECAST ASSUMPTIONS

PASSENGER YIELDS

	REVENUE PER PASSENGER MILE					
	DOMESTIC		INTERNATIONAL		SYSTEM	
FISCAL YEAR	CURRENT $ (Cents)	FY 2022 $ (Cents)	CURRENT $ (Cents)	FY 2022 $ (Cents)	CURRENT $ (Cents)	FY 2022 $ (Cents)
Historical						
2010	12.62	16.70	12.84	16.98	12.69	16.79
2015	14.79	17.97	14.16	17.21	14.59	17.73
2019	14.12	15.97	13.47	15.23	13.92	15.75
2020	13.46	15.00	13.48	15.02	13.46	15.01
2021	11.73	12.66	12.84	13.86	11.93	12.87
2022E	15.58	15.58	15.33	15.33	15.52	15.52
Forecast						
2023	15.66	14.89	15.63	14.87	15.65	14.89
2028	16.73	14.26	16.56	14.11	16.68	14.21
2033	17.63	13.53	17.80	13.68	17.68	13.57
2038	18.54	12.80	19.12	13.24	18.73	12.93
2043	19.57	12.13	20.57	12.81	19.88	12.32
Avg Annual Growth						
2010-22	1.8%	-0.6%	1.5%	-0.9%	1.7%	-0.7%
2022-23	0.5%	-4.4%	2.0%	-3.0%	0.8%	-4.1%
2023-33	1.2%	-1.0%	1.3%	-0.8%	1.2%	-0.9%
2023-43	1.1%	-1.0%	1.4%	-0.7%	1.2%	-0.9%

Source: Form 41, U.S. Department of Transportation.

TABLE 17

U.S. MAINLINE AIR CARRIER FORECAST ASSUMPTIONS

INTERNATIONAL PASSENGER YIELDS BY REGION

	REVENUE PER PASSENGER MILE							
	ATLANTIC		LATIN AMERICA		PACIFIC		TOTAL INTERNATIONAL	
FISCAL YEAR	CURRENT $ (Cents)	FY 2022 $ (Cents)	CURRENT $ (Cents)	FY 2022 $ (Cents)	CURRENT $ (Cents)	FY 2022 $ (Cents)	CURRENT $ (Cents)	FY 2022 $ (Cents)
Historical								
2010	12.73	16.85	13.33	17.64	12.50	16.54	12.84	16.98
2015	14.64	17.78	14.38	17.47	13.20	16.04	14.16	17.21
2019	14.04	15.88	14.20	16.06	11.63	13.16	13.47	15.23
2020	13.49	15.04	14.60	16.27	11.75	13.10	13.48	15.02
2021	11.82	12.76	12.59	13.58	22.48	24.25	12.84	13.86
2022E	15.66	15.66	14.60	14.60	17.79	17.79	15.33	15.33
Forecast								
2023	16.39	15.58	15.22	14.48	14.24	13.54	15.63	14.87
2028	17.84	15.20	16.33	13.91	14.44	12.30	16.56	14.11
2033	19.30	14.82	17.43	13.39	15.65	12.02	17.80	13.68
2038	20.88	14.46	18.53	12.83	16.97	11.75	19.12	13.24
2043	22.64	14.10	19.74	12.29	18.44	11.48	20.57	12.81
Avg Annual Growth								
2010-22	1.7%	-0.6%	0.8%	-1.6%	3.0%	0.6%	1.5%	-0.9%
2022-23	4.6%	-0.5%	4.3%	-0.8%	-20.0%	-23.9%	2.0%	-3.0%
2023-33	1.6%	-0.5%	1.4%	-0.8%	1.0%	-1.2%	1.3%	-0.8%
2023-43	1.6%	-0.5%	1.3%	-0.8%	1.3%	-0.8%	1.4%	-0.7%

Source: Form 41, U.S. Department of Transportation.

TABLE 18

U.S. MAINLINE AIR CARRIER FORECAST ASSUMPTIONS

JET FUEL PRICES

	DOMESTIC		INTERNATIONAL		SYSTEM	
FISCAL YEAR	CURRENT $ (Cents)	FY 2021 $ (Cents)	CURRENT $ (Cents)	FY 2021 $ (Cents)	CURRENT $ (Cents)	FY 2021 $ (Cents)
Historical						
2010	219.16	289.99	220.12	291.27	219.49	290.43
2015	207.29	251.87	211.77	257.31	208.96	253.90
2019	205.67	232.60	207.82	235.03	206.42	233.45
2020	166.65	185.78	167.21	186.40	166.84	185.99
2021	177.23	191.26	171.82	185.42	175.49	189.37
2022E	309.28	309.28	315.20	315.20	311.24	311.24
Forecast						
2023	283.31	269.47	288.73	274.63	285.11	271.18
2028	291.70	248.52	297.29	253.28	293.56	250.10
2033	320.75	246.15	326.89	250.87	322.79	247.72
2038	340.37	235.05	346.89	239.55	342.53	236.55
2043	366.59	227.23	373.61	231.58	368.92	228.68
Avg Annual Growth						
2010-22	2.9%	0.5%	3.0%	0.7%	3.0%	0.6%
2022-23	-8.4%	-12.9%	-8.4%	-12.9%	-8.4%	-12.9%
2023-33	1.2%	-0.9%	1.2%	-0.9%	1.2%	-0.9%
2023-43	1.3%	-0.8%	1.3%	-0.8%	1.3%	-0.8%

Source: Form 41, U.S. Department of Transportation

TABLE 19

U.S. COMMERCIAL AIR CARRIERS

AIR CARGO REVENUE TON MILES[1, 2, 3]

	ALL-CARGO CARRIER RTMS (Millions)			PASSENGER CARRIER RTMS (Millions)			TOTAL RTMS (Millions)		
FISCAL YEAR	DOMESTIC	INT'L.	TOTAL	DOMESTIC	INT'L.	TOTAL	DOMESTIC	INT'L.	TOTAL
Historical									
2010	11,306	15,971	27,276	1,495	6,246	7,742	12,801	22,217	35,018
2015	11,636	16,359	27,995	1,455	6,277	7,733	13,091	22,636	35,727
2019	14,737	19,668	34,405	1,468	6,984	8,452	16,205	26,652	42,856
2020	16,663	21,964	38,627	1,124	4,130	5,255	17,787	26,094	43,882
2021	18,555	26,580	45,135	1,318	4,836	6,154	19,873	31,416	51,289
2022E	18,376	26,090	44,466	1,442	5,625	7,067	19,818	31,715	51,533
Forecast									
2023	18,345	25,253	43,598	1,547	6,407	7,953	19,892	31,660	51,551
2028	20,404	29,147	49,550	1,648	8,700	10,348	22,052	37,846	59,898
2033	22,582	35,036	57,619	1,746	9,731	11,476	24,328	44,767	69,095
2038	25,285	42,089	67,374	1,867	10,844	12,711	27,152	52,933	80,085
2043	28,223	50,233	78,456	1,986	11,965	13,951	30,210	62,198	92,407
Avg Annual Growth									
2010-22	4.1%	4.2%	4.2%	-0.3%	-0.9%	-0.8%	3.7%	3.0%	3.3%
2022-23	-0.2%	-3.2%	-2.0%	7.3%	13.9%	12.5%	0.4%	-0.2%	0.0%
2023-33	2.1%	3.3%	2.8%	1.2%	4.3%	3.7%	2.0%	3.5%	3.0%
2023-43	2.2%	3.5%	3.0%	1.3%	3.2%	2.8%	2.1%	3.4%	3.0%

Source: Form 41, U.S. Department of Transportation

[1]Includes freight/express and mail revenue ton miles on mainline air carriers and regionals/commuters.

[2]Domestic figures from 2000 through 2002 exclude Airborne Express, Inc.; international figures for 2003 and beyond include new reporting of contract service by U.S. carriers for foreign flag carriers.

[3]Domestic figures from 2003 and beyond include Airborne Express. Inc.

TABLE 20

U.S. COMMERCIAL AIR CARRIERS

INTERNATIONAL AIR CARGO REVENUE TON MILES BY REGION[1, 2]

FISCAL YEAR	ATLANTIC (MILLIONS)	LATIN AMERICA (MILLIONS)	PACIFIC (MILLIONS)	OTHER INTERNATIONAL (MILLIONS)	TOTAL (MILLIONS)
Historical					
2010	6,786	1,990	7,897	5,545	22,217
2015	6,627	1,639	9,018	5,352	22,636
2019	7,426	1,661	10,429	7,135	26,652
2020	6,669	1,296	10,198	7,931	26,094
2021	7,603	1,608	11,555	10,650	31,416
2022E	8,763	1,666	10,905	10,382	31,715
Forecast					
2023	8,914	1,699	11,346	9,700	31,660
2028	9,981	1,863	14,154	11,848	37,846
2033	11,281	2,031	16,702	14,753	44,767
2038	12,804	2,237	19,623	18,269	52,933
2043	14,528	2,413	22,832	22,425	62,198
Avg Annual Growth					
2010-22	2.2%	-1.5%	2.7%	5.4%	3.0%
2022-23	1.7%	2.0%	4.0%	-6.6%	-0.2%
2023-33	2.4%	1.8%	3.9%	4.3%	3.5%
2023-43	2.5%	1.8%	3.6%	4.3%	3.4%

Source: Form 41, U.S. Department of Transportation

[1]Includes freight/express and mail revenue ton miles on mainline air carriers and regionals/commuters.

[2]Figures for 2003 and beyond include new reporting of contract service by U.S. carriers for foreign flag carriers.

TABLE 21

U.S. MAINLINE AIR CARRIERS

PASSENGER JET AIRCRAFT

Passenger	LARGE NARROWBODY				LARGE WIDEBODY						
CALENDAR YEAR	2 ENGINE	3 ENGINE	4 ENGINE	TOTAL	2 ENGINE	3 ENGINE	4 ENGINE	TOTAL	LARGE JETS	REGIONAL JETS	TOTAL JETS
Historical											
2010	3,120	8	1	3,129	470	9	43	522	3,651	71	3,722
2015	3,319	2	0	3,321	492	0	31	523	3,844	99	3,943
2019	3,775	0	0	3,775	553	0	0	553	4,328	60	4,388
2020	2,860	0	0	2,860	298	0	0	298	3,158	23	3,181
2021	2,828	0	0	2,828	281	0	0	281	3,109	23	3,132
2022	3,429	0	0	3,429	426	0	0	426	3,855	60	3,915
Forecast											
2023	3,745	0	0	3,745	475	0	0	475	4,220	48	4,268
2028	3,568	0	0	3,568	549	0	0	549	4,117	0	4,117
2033	3,827	0	0	3,827	603	0	0	603	4,430	0	4,430
2038	4,367	0	0	4,367	702	0	0	702	5,069	0	5,069
2043	5,099	0	0	5,099	826	0	0	826	5,925	0	5,925
Avg Annual Growth											
2010-22	0.8%	N.A.	N.A.	0.8%	-0.8%	N.A.	N.A.	-1.7%	0.5%	-1.4%	0.4%
2022-23	9.2%	N.A.	N.A.	9.2%	11.5%	N.A.	N.A.	11.5%	9.5%	N.A.	9.0%
2023-33	0.2%	N.A.	N.A.	0.2%	2.4%	N.A.	N.A.	2.4%	0.5%	N.A.	0.4%
2023-43	1.6%	N.A.	N.A.	1.6%	2.8%	N.A.	N.A.	2.8%	1.7%	N.A.	1.7%

Note: N.A. - Not Applicable

TABLE 22

U.S. MAINLINE AIR CARRIERS

CARGO JET AIRCRAFT

	LARGE NARROWBODY				LARGE WIDEBODY				
CALENDAR YEAR	2 ENGINE	3 ENGINE	4 ENGINE	TOTAL	2 ENGINE	3 ENGINE	4 ENGINE	TOTAL	TOTAL
Historical									
2010	153	104	31	288	265	200	97	562	850
2015	228	22	2	252	309	156	72	537	789
2019	216	10	2	228	419	120	112	651	879
2020	200	10	0	210	414	115	109	638	848
2021	213	8	0	221	434	111	110	655	876
2022	219	7	0	226	469	118	122	709	935
Forecast									
2023	239	7	0	246	503	110	125	738	984
2028	332	2	0	334	611	110	130	851	1,185
2033	449	0	0	449	742	110	130	982	1,431
2038	508	0	0	508	996	41	108	1,145	1,653
2043	642	0	0	642	1,233	7	92	1,332	1,974
Avg Annual Growth									
2010-22	3.0%	-20.1%	N.A.	-2.0%	4.9%	-4.3%	1.9%	2.0%	0.8%
2022-23	9.1%	0.0%	N.A.	8.8%	7.2%	-6.8%	2.5%	4.1%	5.2%
2023-33	6.5%	N.A.	N.A.	6.2%	4.0%	0.0%	0.4%	2.9%	3.8%
2023-43	5.1%	N.A.	N.A.	4.9%	4.6%	-12.9%	-1.5%	3.0%	3.5%

Note: N.A. - Not Applicable

TABLE 23

TOTAL JET FUEL AND AVIATION GASOLINE FUEL CONSUMPTION

U.S. CIVIL AVIATION AIRCRAFT

(Millions of Gallons)

	JET FUEL					AVIATION GASOLINE			
	U.S. AIR CARRIERS[1, 2]								
FISCAL YEAR	DOMESTIC	INT'L.	TOTAL	GENERAL AVIATION	TOTAL	AIR CARRIER	GENERAL AVIATION	TOTAL	TOTAL FUEL CONSUMED
Historical									
2010	12,036	6,315	18,351	1,435	19,786	2	221	223	20,009
2015	12,834	6,541	19,374	1,383	20,757	2	196	198	20,955
2019	14,648	7,043	21,691	1,510	23,202	2	200	202	23,404
2020	10,538	4,732	15,270	1,342	16,612	2	204	206	16,818
2021	11,578	4,823	16,402	1,909	18,311	2	229	231	18,542
2022E	14,008	6,077	20,086	1,936	22,022	2	224	226	22,248
Forecast									
2023	14,794	6,873	21,668	1,964	23,632	2	222	224	23,856
2028	15,239	8,262	23,502	2,167	25,669	2	211	213	25,882
2033	16,679	8,998	25,677	2,392	28,070	2	206	208	28,278
2038	18,710	9,791	28,501	2,608	31,109	2	201	203	31,312
2043	21,218	10,587	31,804	2,810	34,614	2	198	200	34,815
Avg Annual Growth									
2010-22	1.3%	-0.3%	0.8%	2.5%	0.9%	0.0%	0.1%	0.1%	0.9%
2022-23	5.6%	13.1%	7.9%	1.4%	7.3%	0.0%	-1.1%	-1.1%	7.2%
2023-33	1.2%	2.7%	1.7%	2.0%	1.7%	0.0%	-0.7%	-0.7%	1.7%
2023-43	1.8%	2.2%	1.9%	1.8%	1.9%	0.0%	-0.6%	-0.6%	1.9%

Source: Air carrier jet fuel, Form 41, U.S. Department of Transportation; all others, FAA APO estimates.

[1]Includes both passenger (mainline and regional air carrier) and cargo carriers.

[2]Forecast assumes 1.0% annual improvement in available seat miles per gallon for U.S. Commercial Air Carrier

TABLE 24

U.S. REGIONAL CARRIER FORECAST ASSUMPTIONS

	AVERAGE SEATS PER AIRCRAFT MILE			AVERAGE PASSENGER TRIP LENGTH			REVENUE PER PASSENGER MILE**	
FISCAL YEAR	DOMESTIC (Seats/Mile)	INT'L (Seats/Mile)	TOTAL (Seats/Mile)	DOMESTIC (Miles)	INT'L. (Miles)	TOTAL (Miles)	CURRENT $ (Cents)	2022 $ (Cents)
Historical								
2010	55.7	53.2	55.7	459	503	460	16.23	21.48
2015	59.5	64.9	59.7	469	695	473	11.41	13.86
2019	64.1	72.5	64.3	491	670	495	12.15	13.74
2020	65.0	71.9	65.1	494	675	497	11.65	12.99
2021	66.5	72.9	66.6	509	662	512	10.20	11.01
2022E	66.9	72.5	67.0	490	640	492	13.53	13.53
Forecast								
2023	70.2	72.8	70.3	495	648	498	13.60	12.93
2028	71.5	74.3	71.6	502	656	505	14.52	12.37
2033	72.7	75.8	72.8	509	665	511	15.29	11.74
2038	73.9	77.3	74.0	515	674	518	16.09	11.11
2043	75.1	78.8	75.2	522	683	525	16.98	10.52
Avg Annual Growth								
2010-22	1.5%	2.6%	1.6%	0.5%	2.0%	0.6%	-1.5%	-3.8%
2022-23	4.9%	0.4%	4.8%	1.2%	1.2%	1.2%	0.5%	-4.4%
2023-33	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	1.2%	-1.0%
2023-43	0.3%	0.4%	0.3%	0.3%	0.3%	0.3%	1.1%	-1.0%

Source: Form 41 and 298C, U.S. Department of Transportation.

** Reporting carriers.

TABLE 25

U.S. REGIONAL CARRIERS

SCHEDULED PASSENGER TRAFFIC

(In Millions)

	REVENUE PASSENGERS			REVENUE PASSENGER MILES		
FISCAL YEAR	DOMESTIC	INTERNATIONAL	TOTAL	DOMESTIC	INTERNATIONAL	TOTAL
Historical						
2010	158	3	161	72,709	1,347	74,055
2015	149	3	152	69,619	2,116	71,735
2019	152	4	156	74,791	2,376	77,168
2020	92	2	94	45,538	1,229	46,767
2021	105	2	107	53,650	1,221	54,871
2022E	126	2	128	61,725	1,335	63,060
Forecast						
2023	151	3	154	74,949	1,621	76,570
2028	164	3	167	82,307	1,780	84,088
2033	189	3	192	95,902	2,074	97,977
2038	219	4	223	112,940	2,443	115,383
2043	258	4	262	134,656	2,913	137,568
Avg Annual Growth						
2010-22	-1.9%	-2.1%	-1.9%	-1.4%	-0.1%	-1.3%
2022-23	20.0%	20.0%	20.0%	21.4%	21.4%	21.4%
2023-33	2.2%	2.2%	2.2%	2.5%	2.5%	2.5%
2023-43	2.7%	2.7%	2.7%	3.0%	3.0%	3.0%

Source: Form 41 and 298C, U.S. Department of Transportation.

TABLE 26

U.S. REGIONAL CARRIERS

SCHEDULED PASSENGER CAPACITY, TRAFFIC, AND LOAD FACTORS

	DOMESTIC			INTERNATIONAL			TOTAL		
YEAR	ASMs (MIL)	RPMs (MIL)	% LOAD FACTOR	ASMs (MIL)	RPMs (MIL)	% LOAD FACTOR	ASMs (MIL)	RPMs (MIL)	% LOAD FACTOR
Historical									
2010	95,508	72,709	76.1	1,857	1,347	72.5	97,365	74,055	76.1
2015	86,778	69,619	80.2	2,819	2,116	75.0	89,597	71,735	80.1
2019	93,720	74,791	79.8	3,116	2,376	76.3	96,836	77,168	79.7
2020	69,317	45,538	65.7	1,812	1,229	67.9	71,129	46,767	65.8
2021	75,837	53,650	70.7	1,836	1,221	66.5	77,673	54,871	70.6
2022E	77,700	61,725	79.4	1,833	1,335	72.8	79,533	63,060	79.3
Forecast									
2023	94,741	74,949	79.1	2,235	1,621	72.5	96,975	76,570	79.0
2028	102,567	82,307	80.2	2,419	1,780	73.6	104,986	84,088	80.1
2033	117,984	95,902	81.3	2,783	2,074	74.5	120,767	97,977	81.1
2038	139,104	112,940	81.2	3,281	2,443	74.5	142,385	115,383	81.0
2043	165,792	134,656	81.2	3,911	2,913	74.5	169,703	137,568	81.1
Avg Annual Growth									
2010-22	-1.7%	-1.4%		-0.1%	-0.1%		-1.7%	-1.3%	
2022-23	21.9%	21.4%		21.9%	21.4%		21.9%	21.4%	
2023-33	2.2%	2.5%		2.2%	2.5%		2.2%	2.5%	
2023-43	2.8%	3.0%		2.8%	3.0%		2.8%	3.0%	

Source: Form 41 and 298C, U.S. Department of Transportation.

TABLE 27

U.S. REGIONAL CARRIERS

PASSENGER AIRCRAFT

	REGIONAL AIRCRAFT											
				31 TO 40 SEATS			OVER 40 SEATS			TOTAL FLEET		
AS OF JANUARY 1	LESS THAN 9 SEATS	10 TO 19 SEATS	20 TO 30 SEATS	PROP	JET	TOTAL	PROP	JET	TOTAL	NON JET	JET	TOTAL
Historical												
2010	440	92	82	144	28	172	99	1,728	1,827	857	1,756	2,613
2015	346	68	13	32	0	32	57	1,628	1,685	516	1,628	2,144
2019	374	72	19	11	0	11	39	1,846	1,885	515	1,846	2,361
2020	276	74	20	11	0	11	40	1,434	1,474	421	1,434	1,855
2021	268	69	16	10	0	10	38	1,406	1,444	401	1,406	1,807
2022	247	59	18	3	3	6	49	1,623	1,672	376	1,626	2,002
Forecast												
2023	211	54	13	0	1	1	56	1,635	1,691	334	1,636	1,970
2028	183	47	11	0	0	0	58	1,499	1,557	299	1,499	1,798
2033	158	41	9	0	0	0	64	1,566	1,630	272	1,566	1,838
2038	135	35	8	0	0	0	70	1,849	1,919	248	1,849	2,097
2043	113	29	7	0	0	0	80	2,158	2,238	229	2,158	2,387
Avg Annual Growth												
2010-22	-4.7%	-3.6%	-11.9%	-27.6%	-17.0%	-24.4%	-5.7%	-0.5%	-0.7%	-6.6%	-0.6%	-2.2%
2022-23	-14.6%	-8.5%	-27.8%	N.A.	-66.7%	-83.3%	14.3%	0.7%	1.1%	-11.2%	0.6%	-1.6%
2023-33	-2.9%	-2.7%	-3.6%	N.A.	N.A.	N.A.	1.3%	-0.4%	-0.4%	-2.0%	-0.4%	-0.7%
2023-43	-3.1%	-3.1%	-3.0%	N.A.	N.A.	N.A.	1.8%	1.4%	1.4%	-1.9%	1.4%	1.0%

Note: N.A. - Not Applicable

TABLE 28

ACTIVE GENERAL AVIATION AND AIR TAXI AIRCRAFT

	FIXED WING						ROTORCRAFT						TOTAL		
	PISTON			TURBINE									GENERAL		
AS OF DEC. 31	SINGLE ENGINE	MULTI-ENGINE	TOTAL	TURBO PROP	TURBO JET	TOTAL	PISTON	TURBINE	TOTAL	MENTAL**	LIGHT SPORT AIRCRAFT**	OTHER	AVIATION FLEET	TOTAL PISTONS	TOTAL TURBINES
Historical*															
2010	139,519	15,900	155,419	9,369	11,484	20,853	3,588	6,514	10,102	24,784	6,528	5,684	223,370	159,007	27,367
2015	127,887	13,254	141,141	9,712	13,440	23,152	3,286	7,220	10,506	27,922	2,369	4,941	210,031	144,427	30,372
2019	128,926	12,470	141,396	10,242	14,888	25,130	3,089	7,109	10,198	27,449	2,675	4,133	210,981	144,485	32,239
2020	124,059	11,947	136,006	10,317	15,316	25,633	2,930	6,816	9,746	26,367	2,570	3,818	204,140	138,936	32,449
2021	126,735	11,885	138,620	10,391	15,270	25,661	3,012	7,020	10,032	27,960	2,650	4,271	209,194	141,632	32,681
2022E	125,655	11,810	137,465	10,415	15,730	26,145	3,020	7,155	10,175	28,245	2,760	4,350	209,140	140,485	33,300
Forecast															
2023	124,545	11,745	136,290	10,430	16,215	26,645	3,030	7,290	10,320	28,580	2,870	4,390	209,095	139,320	33,935
2028	119,185	11,485	130,670	10,560	18,930	29,490	3,090	8,030	11,120	30,190	3,450	4,590	209,510	133,760	37,520
2033	114,360	11,315	125,675	10,885	21,775	32,660	3,175	8,830	12,005	31,410	4,050	4,655	210,455	128,850	41,490
2038	110,405	11,205	121,610	11,410	24,655	36,065	3,275	9,655	12,930	32,600	4,610	4,695	212,510	124,885	45,720
2043	107,800	11,175	118,975	12,170	27,570	39,740	3,375	10,495	13,870	33,835	5,245	4,730	216,395	122,350	50,235
Avg Annual Growth															
2010-22	-0.9%	-2.4%	-1.0%	0.9%	2.7%	1.9%	-1.4%	0.8%	0.1%	1.1%	-6.9%	-2.2%	-0.5%	-1.0%	1.6%
2022-23	-0.9%	-0.6%	-0.9%	0.1%	3.1%	1.9%	0.3%	1.9%	1.4%	1.2%	4.0%	0.9%	0.0%	-0.8%	1.9%
2023-33	-0.8%	-0.4%	-0.8%	0.4%	3.0%	2.1%	0.5%	1.9%	1.5%	0.9%	3.5%	0.6%	0.1%	-0.8%	2.0%
2023-43	-0.7%	-0.2%	-0.7%	0.8%	2.7%	2.0%	0.5%	1.8%	1.5%	0.8%	3.1%	0.4%	0.2%	-0.6%	2.0%

* Source: 2001-2010, 2012-2021, FAA General Aviation and Air Taxi Activity (and Avionics) Surveys.

**Experimental Light-sport category that was previously shown under Sport Aircraft is moved under Experimental Aircraft category, starting in 2012.

Note: An active aircraft is one that has a current registration and was flown at least one hour during the calendar year.

TABLE 29

ACTIVE GENERAL AVIATION AND AIR TAXI HOURS FLOWN

(In Thousands)

	FIXED WING						ROTORCRAFT						TOTAL		
	PISTON			TURBINE									GENERAL		
AS OF DEC. 31	SINGLE ENGINE	MULTI-ENGINE	TOTAL	TURBO PROP	TURBO JET	TOTAL	PISTON	TURBINE	TOTAL	EXPERI-MENTAL**	LIGHT SPORT AIRCRAFT**	OTHER	AVIATION HOURS	TOTAL PISTONS	TURBINES
Historical*															
2010	12,161	1,818	13,979	2,325	3,375	5,700	794	2,611	3,405	1,226	311	181	24,802	14,773	8,311
2015	11,217	1,608	12,825	2,538	3,837	6,375	798	2,496	3,294	1,295	191	162	24,142	13,623	8,871
2019	12,700	1,731	14,431	2,619	3,926	6,546	628	2,369	2,997	1,269	189	135	25,566	15,059	8,914
2020	11,603	1,336	12,939	2,344	3,336	5,681	537	1,871	2,408	1,176	202	86	22,492	13,477	7,552
2021	12,808	1,494	14,302	2,720	4,868	7,587	578	2,178	2,756	1,394	245	156	26,441	14,880	9,765
2022E	12,505	1,532	14,036	2,793	4,968	7,760	592	2,242	2,833	1,304	228	137	26,299	14,628	10,002
Forecast															
2023	12,240	1,549	13,789	2,847	5,087	7,934	605	2,307	2,912	1,349	240	142	26,366	14,394	10,241
2028	11,336	1,544	12,880	2,967	5,965	8,933	660	2,623	3,284	1,511	300	155	27,062	13,540	11,556
2033	10,910	1,549	12,458	3,063	6,911	9,974	708	2,922	3,630	1,611	362	159	28,195	13,166	12,896
2038	10,553	1,564	12,118	3,212	7,845	11,057	749	3,220	3,968	1,693	421	161	29,419	12,867	14,277
2043	10,306	1,597	11,903	3,427	8,769	12,195	786	3,526	4,312	1,777	487	163	30,838	12,690	15,721
Avg Annual Growth															
2010-22	0.2%	-1.4%	0.0%	1.5%	3.3%	2.6%	-2.4%	-1.3%	-1.5%	0.5%	-2.6%	-2.3%	0.5%	-0.1%	1.6%
2022-23	-2.1%	1.1%	-1.8%	1.9%	2.4%	2.2%	2.3%	2.9%	2.8%	3.4%	5.6%	3.4%	0.3%	-1.6%	2.4%
2023-33	-1.1%	0.0%	-1.0%	0.7%	3.1%	2.3%	1.6%	2.4%	2.2%	1.8%	4.2%	1.1%	0.7%	-0.9%	2.3%
2023-43	-0.9%	0.2%	-0.7%	0.9%	2.8%	2.2%	1.3%	2.1%	2.0%	1.4%	3.6%	0.7%	0.8%	-0.6%	2.2%

* Source: 2001-2010, 2012-2021, FAA General Aviation and Air Taxi Activity (and Avionics) Surveys.

**Experimental Light-sport category that was previously shown under Sport Aircraft is moved under Experimental Aircraft category, starting in 2012.

Note: An active aircraft is one that has a current registration and was flown at least one hour during the calendar year.

TABLE 30

ACTIVE PILOTS BY TYPE OF CERTIFICATE, EXCLUDING STUDENT PILOTS*

AS OF DEC. 31	RECREA-TIONAL	SPORT PILOT	PRIVATE	COMMERCIAL	AIRLINE TRANSPORT	ROTOR-CRAFT ONLY	GLIDER ONLY	TOTAL LESS STUDENT PILOTS	INSTRUMENT RATED PILOTS[1]
Historical**									
2010	212	3,682	202,020	123,705	142,198	15,377	21,275	508,469	318,001
2015	190	5,482	170,718	101,164	154,730	15,566	19,460	467,310	304,329
2019	127	6,467	161,105	100,863	164,947	14,248	19,143	466,900	314,168
2020	105	6,643	160,860	103,879	164,193	13,629	19,753	469,062	316,651
2021	85	6,801	161,459	104,610	163,934	13,191	20,328	470,408	317,169
2022	79	6,957	164,090	104,498	166,738	13,180	20,804	476,346	321,217
Forecast									
2023	75	7,150	166,000	104,700	169,900	13,100	21,100	482,025	324,700
2028	70	8,385	168,700	105,050	178,800	13,100	22,050	496,155	332,800
2033	55	9,575	166,750	104,950	183,400	13,950	22,550	501,230	342,200
2038	40	10,685	163,350	104,700	189,200	14,950	22,750	505,675	351,700
2043	15	11,705	159,650	104,450	196,100	15,900	22,850	510,670	361,250
Avg Annual Growth									
2010-22	-7.9%	5.4%	-1.7%	-1.4%	1.3%	-1.3%	-0.2%	-0.5%	0.1%
2022-23	-5.1%	2.8%	1.2%	0.2%	1.9%	-0.6%	1.4%	1.2%	1.1%
2023-33	-3.1%	3.0%	0.0%	0.0%	0.8%	0.6%	0.7%	0.4%	0.5%
2023-43	-7.7%	2.5%	-0.2%	0.0%	0.7%	1.0%	0.4%	0.3%	0.5%

** Source: FAA U.S. Civil Airmen Statistics.

*Starting with April 2016, there is no expiration date on the new student pilot certificates. This generates a cumulative increase in the student pilot numbers and breaks the link between student pilot and private pilot or higher level certificates. Since there is no sufficient data yet to forecast the student certificates unter the new rule, student pilot forecast is suspended and excluded from this table.

[1]Instrument rated pilots should not be added to other categories in deriving total.

Note: An active pilot is a person with a pilot certificate and a valid medical certificate.

TABLE 31

GENERAL AVIATION AIRCRAFT FUEL CONSUMPTION

(In Millions of Gallons)

	FIXED WING										
	PISTON		TURBINE		ROTORCRAFT				TOTAL FUEL CONSUMED		
CALENDAR YEAR	SINGLE ENGINE	MULTI-ENGINE	TURBO PROP	TURBO JET	PISTON	TURBINE	EXPERI-MENTAL* * / OTHER	LIGHT SPORT**	AVGAS	JET FUEL	TOTAL
Historical*											
2010	133	54	187	1,123	11	125	22	1	221	1,435	1,656
2015	128	40	191	1,063	10	128	15	1	196	1,383	1,578
2019	131	45	213	1,170	8	127	16	1	200	1,510	1,711
2020	146	35	201	1,036	8	105	14	1	204	1,342	1,546
2021	155	47	230	1,557	8	123	18	1	229	1,909	2,138
2022E	151	48	235	1,576	8	125	16	1	224	1,936	2,160
Forecast											
2023	147	48	238	1,598	8	128	17	1	222	1,964	2,186
2028	135	47	244	1,781	9	142	19	2	211	2,167	2,379
2033	129	46	247	1,992	10	154	20	2	206	2,392	2,599
2038	122	46	253	2,192	10	163	20	2	201	2,608	2,809
2043	118	46	264	2,375	11	171	21	3	198	2,810	3,008
Avg Annual Growth											
2010-22	1.0%	-0.9%	1.9%	2.9%	-2.3%	0.0%	-2.4%	-0.8%	0.1%	2.5%	2.2%
2022-23	-2.3%	0.7%	1.5%	1.4%	2.2%	2.1%	3.0%	5.6%	-1.1%	1.4%	1.2%
2023-33	-1.3%	-0.5%	0.3%	2.2%	1.5%	1.9%	1.7%	3.6%	-0.7%	2.0%	1.7%
2023-43	-1.1%	-0.3%	0.5%	2.0%	1.2%	1.5%	1.3%	3.1%	-0.6%	1.8%	1.6%

*Source: FAA APO Estimates.

**Experimental Light-sport category that was previously shown under Sport Aircraft is moved under Experimental Aircraft category, starting in 2012.

Note: Detail may not add to total because of independent rounding.

TABLE 32

TOTAL COMBINED AIRCRAFT OPERATIONS AT AIRPORTS WITH FAA AND CONTRACT TRAFFIC CONTROL SERVICE

(In Thousands)

			GENERAL AVIATION			MILITARY				NUMBER OF TOWERS	
FISCAL YEAR	AIR CARRIER	AIR TAXI/ COMMUTER	ITINERANT	LOCAL	TOTAL	ITINERANT	LOCAL	TOTAL	TOTAL	FAA	CONTRACT
Historical											
2010	12,658	9,410	14,864	11,716	26,580	1,309	1,298	2,607	51,255	264	244
2015	13,755	7,895	13,887	11,691	25,579	1,292	1,203	2,495	49,724	264	252
2019	16,192	7,234	14,245	13,109	27,354	1,349	1,134	2,483	53,264	264	256
2020	11,737	5,472	12,608	12,333	24,941	1,192	1,020	2,212	44,362	264	256
2021	12,214	5,885	13,775	13,479	27,254	1,290	1,077	2,366	47,720	264	258
2022	15,150	6,522	14,635	14,029	28,664	1,288	986	2,254	52,591	264	260
Forecast											
2023	16,626	6,040	15,078	14,802	29,880	1,269	986	2,255	54,800	264	260
2028	20,164	6,073	16,068	15,768	31,835	1,269	986	2,255	60,327	264	260
2033	22,248	6,401	16,274	16,043	32,318	1,269	986	2,255	63,222	264	260
2038	24,408	6,742	16,486	16,328	32,814	1,269	986	2,255	66,219	264	260
2043	26,748	7,105	16,704	16,622	33,326	1,269	986	2,255	69,435	264	260
Avg Annual Growth											
2010-22	1.5%	-3.0%	-0.1%	1.5%	0.6%	-0.1%	-2.3%	-1.2%	0.2%		
2022-23	9.7%	-7.4%	3.0%	5.5%	4.2%	-1.5%	0.0%	0.0%	4.2%		
2023-33	3.0%	0.6%	0.8%	0.8%	0.8%	0.0%	0.0%	0.0%	1.4%		
2023-43	2.4%	0.8%	0.5%	0.6%	0.5%	0.0%	0.0%	0.0%	1.2%		

Source: FAA Air Traffic Activity.

TABLE 33

TOTAL TRACON OPERATIONS
(In Thousands)

FISCAL YEAR	AIR CARRIER	AIR TAXI/ COMMUTER	GENERAL AVIATION	MILITARY	OVERFLIGHT	TOTAL
Historical						
2010	12,575	8,512	10,761	2,050	4,840	38,738
2015	13,610	6,999	10,350	1,961	4,116	37,036
2019	16,014	6,600	10,960	1,946	3,706	39,227
2020	11,617	5,153	9,691	1,763	3,050	31,274
2021	12,045	5,462	10,742	1,894	3,393	33,536
2022	14,967	5,925	11,376	1,825	3,601	37,694
Forecast						
2023	16,423	5,271	11,682	1,827	3,719	38,922
2028	19,920	4,937	12,299	1,827	4,117	43,101
2033	21,987	5,221	12,441	1,827	4,380	45,856
2038	24,130	5,514	12,586	1,827	4,653	48,710
2043	26,452	5,827	12,734	1,827	4,946	51,786
Avg Annual Growth						
2010-22	1.5%	-3.0%	0.5%	-1.0%	-2.4%	-0.2%
2022-23	9.7%	-11.0%	2.7%	0.1%	3.3%	3.3%
2023-33	3.0%	-0.1%	0.6%	0.0%	1.7%	1.7%
2023-43	2.4%	0.5%	0.4%	0.0%	1.4%	1.4%

Source: FAA Air Traffic Activity.

TABLE 34

IFR AIRCRAFT HANDLED
AT FAA EN ROUTE TRAFFIC CONTROL CENTERS
(In Thousands)

	IFR AIRCRAFT HANDLED			
FISCAL YEAR	COMMERCIAL	GENERAL AVIATION	MILITARY	TOTAL
Historical				
2010	30,965	6,550	2,982	40,498
2015	33,116	7,007	1,795	41,918
2019	35,783	6,309	1,645	43,737
2020	25,608	5,096	1,404	32,108
2021	26,449	6,124	1,525	34,098
2022	32,891	7,034	1,511	41,437
Forecast				
2023	35,961	7,198	1,511	44,670
2028	41,942	7,523	1,511	50,976
2033	46,540	7,725	1,511	55,776
2038	51,294	7,938	1,511	60,742
2043	56,428	8,161	1,511	66,100
Avg Annual Growth				
2010-22	0.5%	0.6%	-5.5%	0.2%
2022-23	9.3%	2.3%	0.0%	7.8%
2023-33	2.6%	0.7%	0.0%	2.2%
2023-43	2.3%	0.6%	0.0%	2.0%

Source: FAA Air Traffic Activity