Emerging Aviation Entrants: Unmanned Aircraft Systems and Advanced Air Mobility

New Entrants: Analysis and Forecasts

Unmanned aircraft systems (UAS or 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 ground 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 numerous possibilities, especially from a commercial perspective, e.g., package deliveries. 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, infrastructure inspections 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 unmanned aircraft[1] 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 from FAA-sponsored and other research, government and industry reports.

[1] 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 flyers, under Section 349, are referred to as "recreational flyers or modeler community-based organizations" [see https://bit.ly/2PUhMCI]. In previous notes including other documents of the Agency, these terms are often interchanged.

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[2] 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.[3]

With the continuing registration, over 1.54 million (new) recreational drone owners had already registered cumulatively with the FAA by end of December, 2023.[4] On average, new owner registration stood at around 6,053 per month during January – December 2023 with some expected peaks during the holiday seasons and summer. In comparison, the year before (in 2022), average new owner registration stood at around 7,866 per month during January – December. Prior to that, during 2021, the average new owner registration per month stood at around 10,200 per month. Clearly, the average monthly registrations have been declining.

As evident, the current pace of new registration (and, presumably, sales of drones requiring registration) has decreased compared to last year in the same period; average new monthly owner registration during 2023 stood at 1,813 less than observed the year before in 2022. In comparison to the year before in 2022, the number stood at 2,334 less than 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. We expect this trend to continue over the forecast horizon of next five years.

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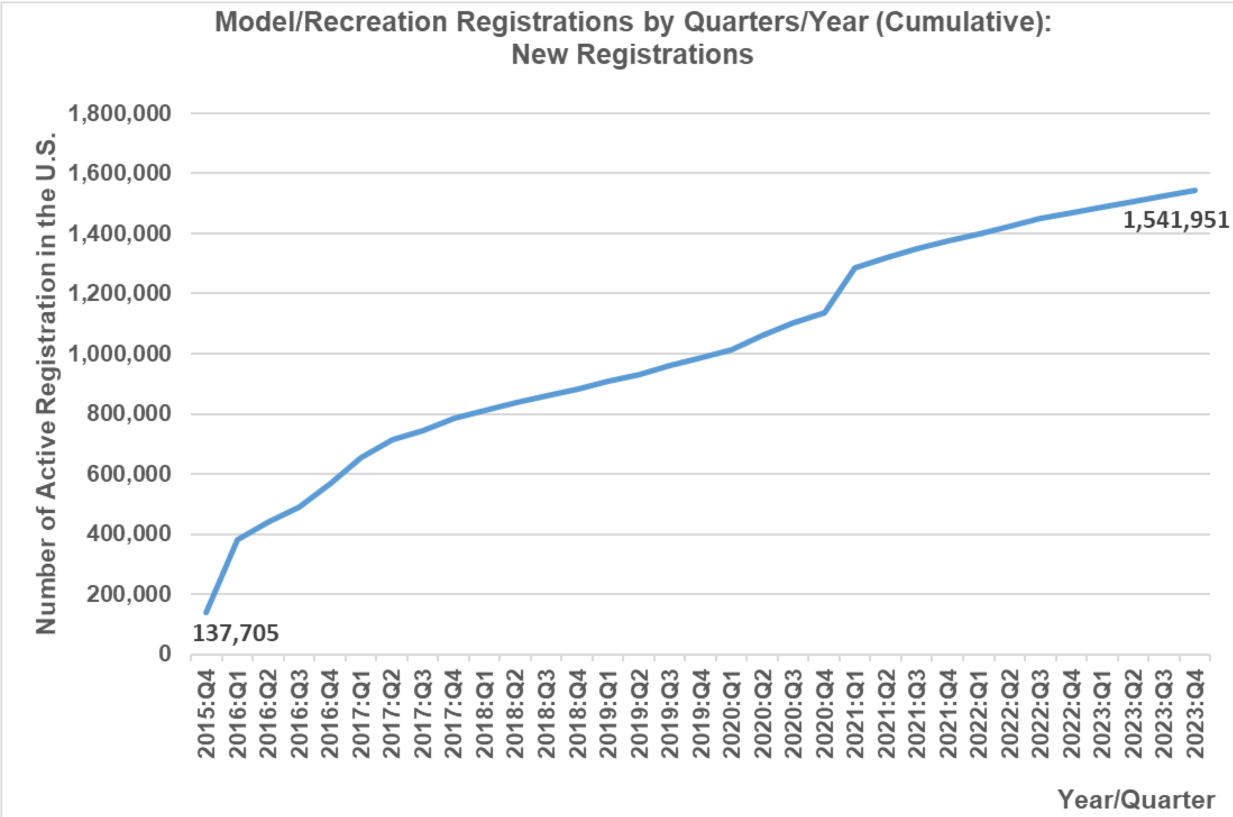
[2] See https://bit.ly/2IfJ1cm.

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

[4] 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, 2023. Furthermore, we draw a clear distinction between new registrations, cancellations, and renewals in this document which have been explained later on.



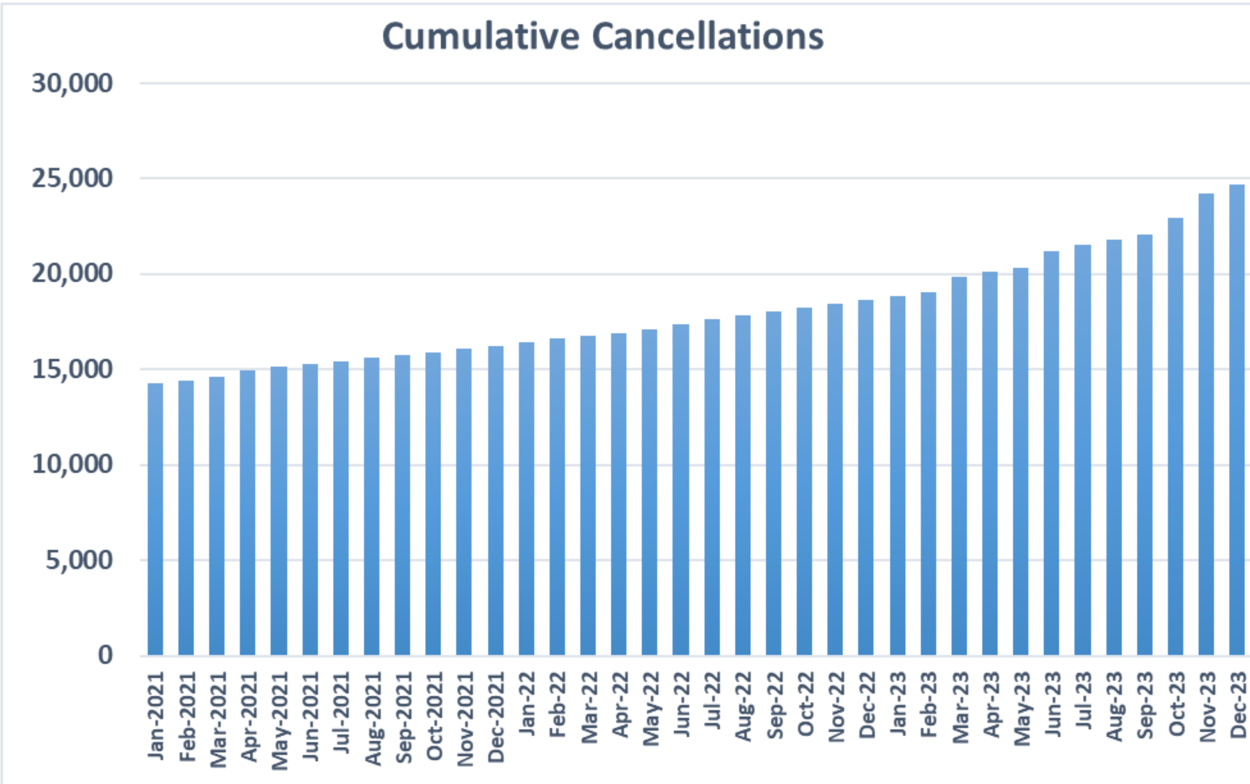
Forecasts Using New Registrations vs. Effective/Active Fleet

As noted in earlier Aerospace Forecast reports, small drones are registered for 3 years while remote pilot (RP) certifications are valid for 2 years.[5] 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.

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

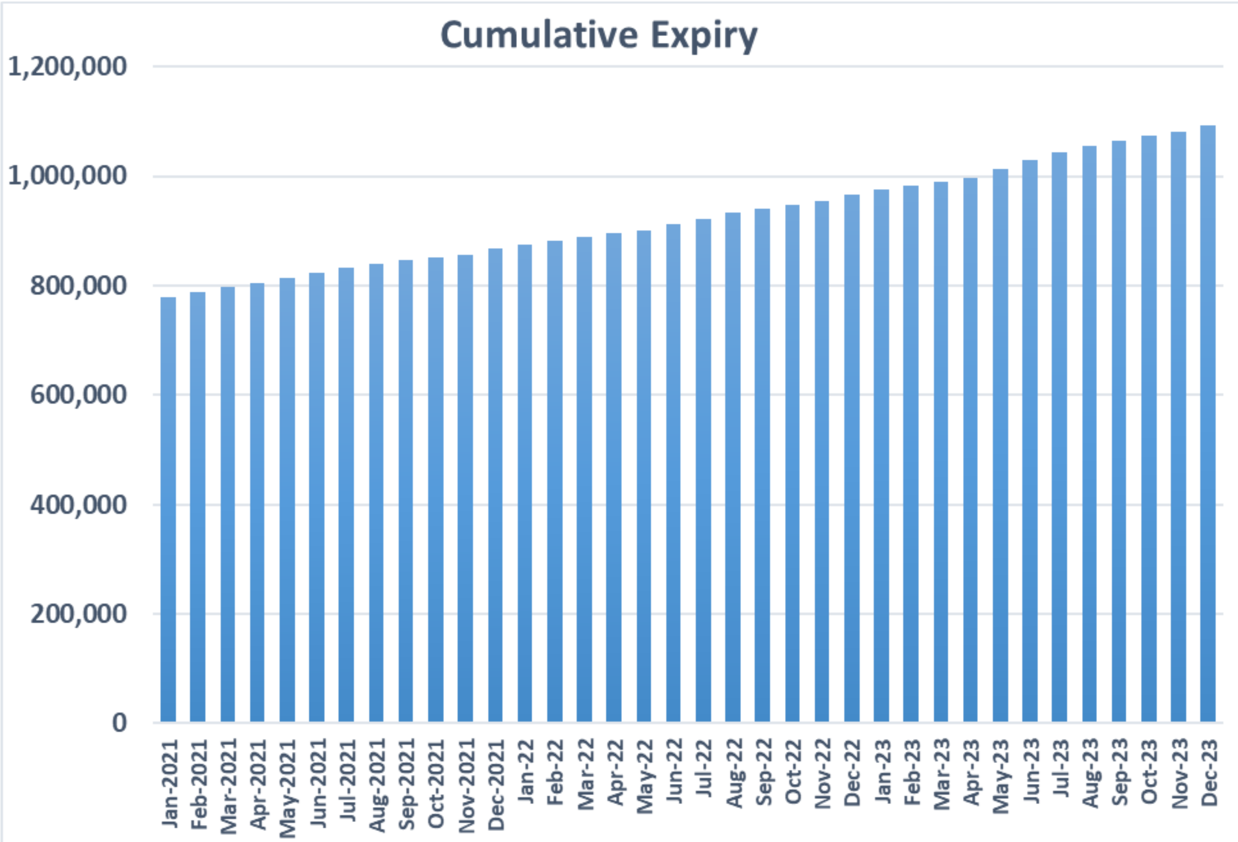
Cumulative cancellations were, on average, 21,379/month for the time period of January 2023 – December 2023 (or averaging around 508 new cancellations, or the average gaps between the two bars in the graph below, for each month during the January – December 2023 timeframe). For the years 2021-2022, the numbers for cumulative cancellations and average new monthly cancellations stood at 16,403 and 188, respectively:[6]



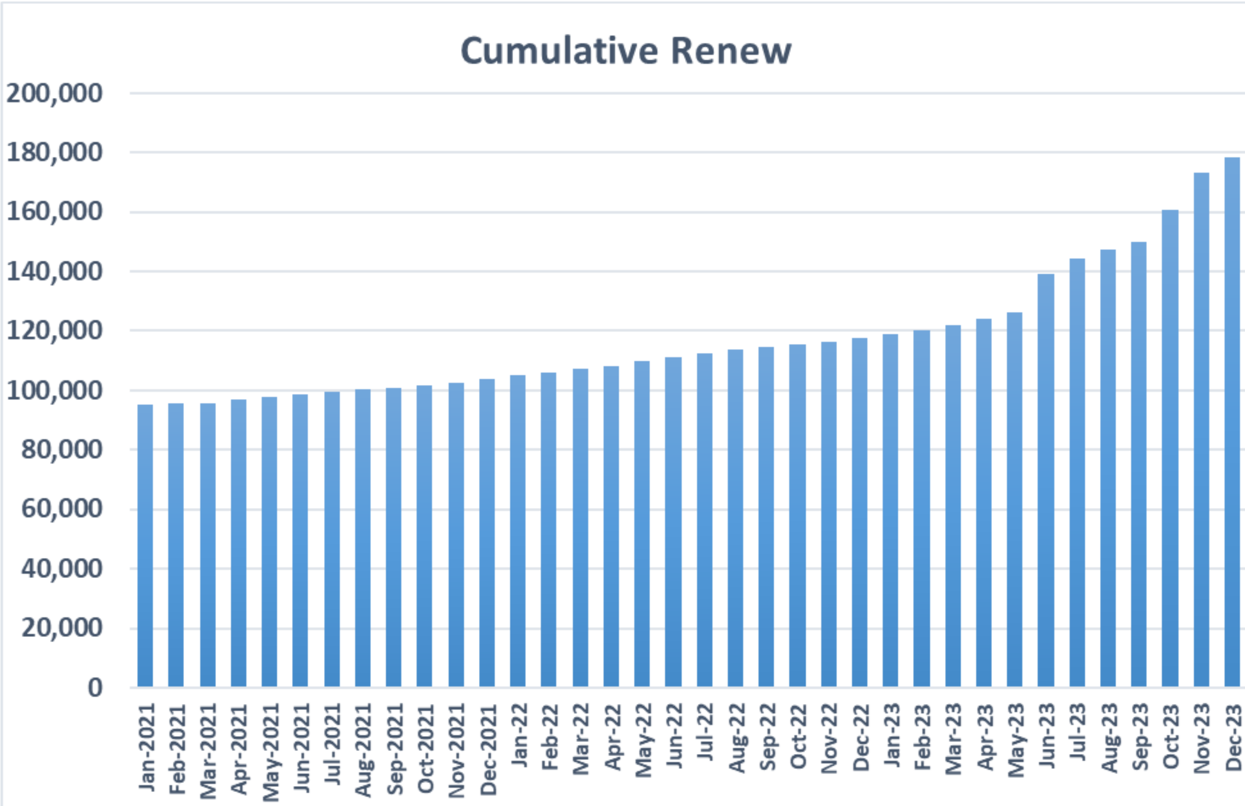
We extend the data by one more year this year to 2023 and observe that trend in cancellations accelerated, from average of 188/month reported last year to over 500/month this year; cumulative cancellations, on average, stood at around 21,379 with new monthly cancellations at 508 during January-December, 2023. These numbers have accelerated during this year to what we observed during 2022.

Likewise, registrations cumulatively expired at a rate over 1 million/month during 2023 following the immediate and substantial adjustment in December 2020, as noted earlier and as shown below. This is equal to a little more than 10,625 new average expirations for each month during January – December 2023; during the years 2021-2022, it was calculated to be 8,336/month:

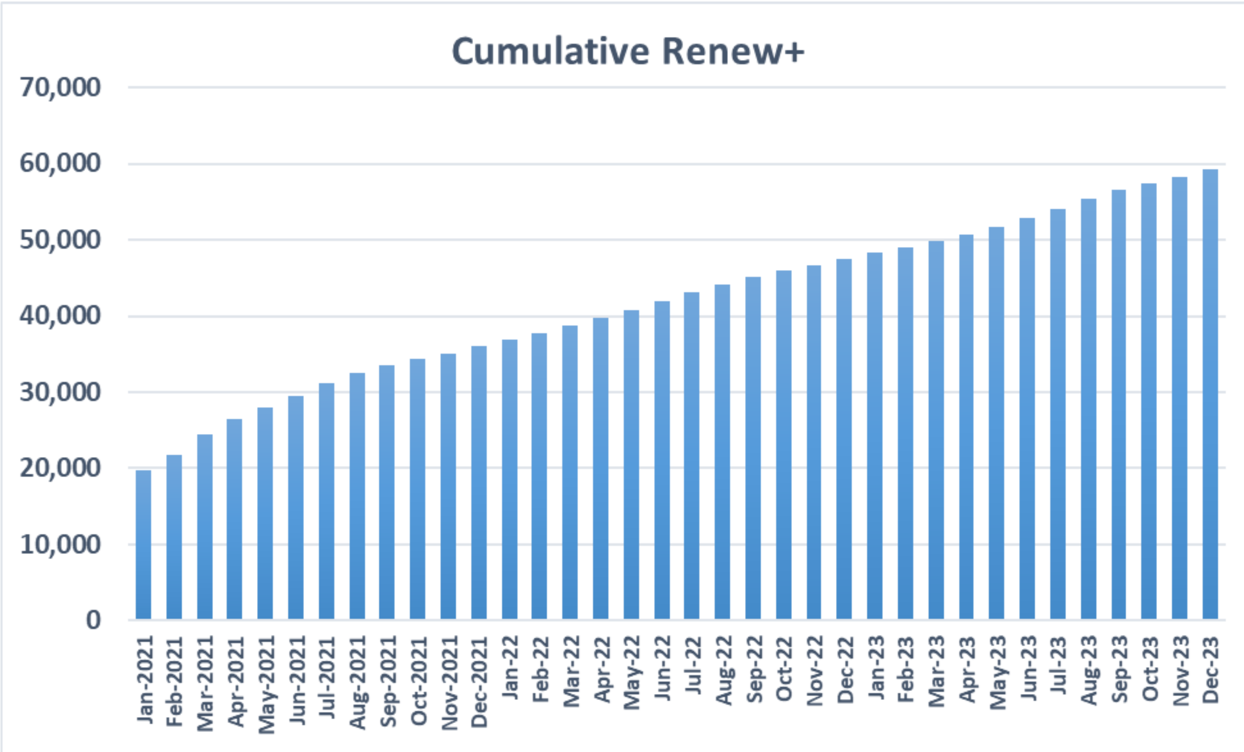
[6] We report cumulative numbers throughout this document for two reasons: first, cumulative numbers reflect the stability of the trend over time, taking into account past changes; and second, differences between the two numbers (i.e., bars from the graph) capture the changes between two particular time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



While cancellations and expiry have been accelerating over these last three years, renewal or re-registrations prior to expiry date has been picking up speed as well. In comparison to last year's (2022) observed 111.445/month on a cumulative basis, this past year (January-December, 2023), renewals further climbed up to 142,000 (or 5,059 new average monthly renewals, in comparison to only 1,170 new average renewals the year before for each month during January – December 2022), over a 4-fold increase in renewal. For the past two years (2022-2023) as a whole, 126,762/month renewed on a cumulative basis with new average renewals correspondingly stood at around 3,115/month. This was almost three times higher than Renew+ on a cumulative basis, as reported below:

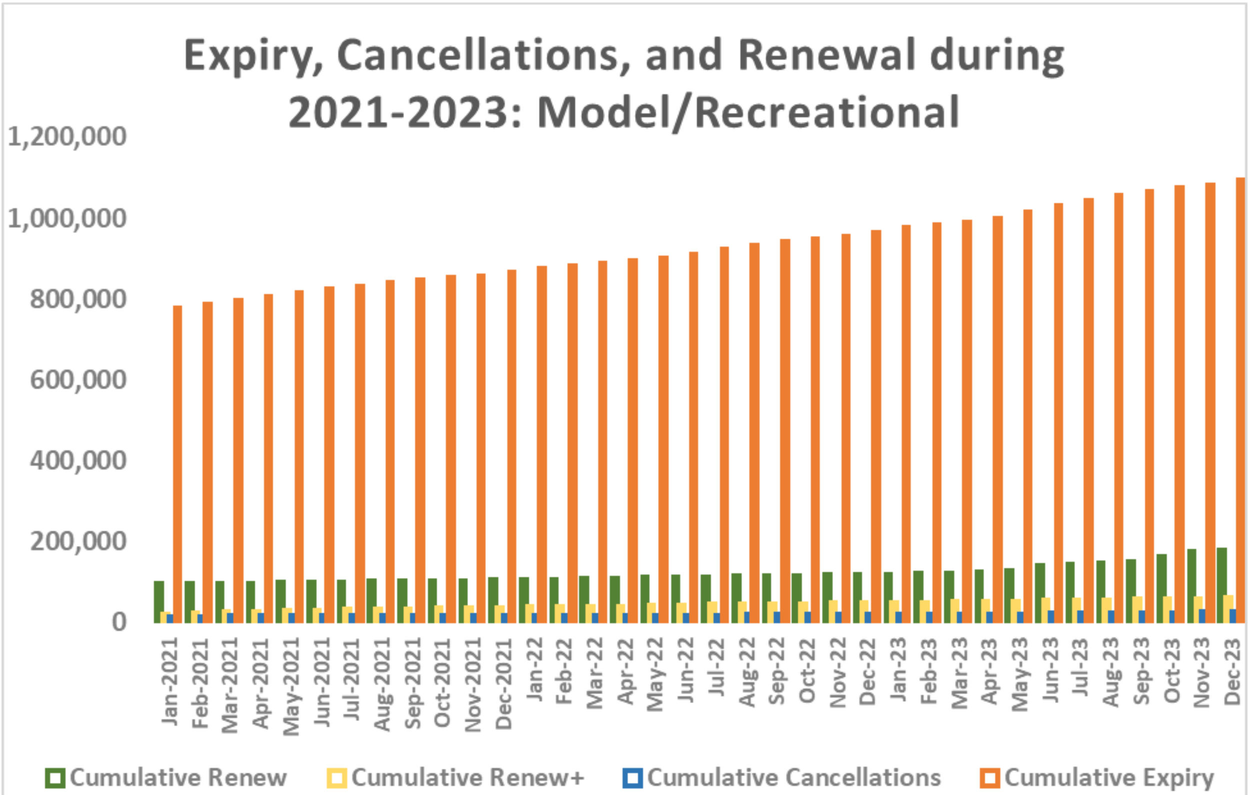


Renew+, re-registrations after expiry date, logged at a cumulative average of 53,638/month during January-December, 2023. This is equivalent to approximately 988 new average Renew+ registrations for each month during January – December 2023 and are reported in below:



For the entirety of three years (2021-2023) in aggregate, cumulative renewal+ stood at 41,798/month with new renewals+ at 1,240/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 with outsized impact on the effective/active registration as discussed below.

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[7] of each element to the day's net gain/loss calculations:[8]

- **Cancel:** (-1 for each registration);
- **Expire:** (-1 for each registration);
- **New:** (+1 for each registration)
- **Renew:** (0); and
- **Renew+:** (+1 for each registration).[9]

An example of this calculation may be constructed as follows: calculating the net gain/loss for recreational registration for August 9, 2023 (an arbitrary date, same as reported last year), where Cancel = 9; Expiry = 377; New = 198; Renew = 105; and Renew+ = 37 were reported for recreational operators/modelers.

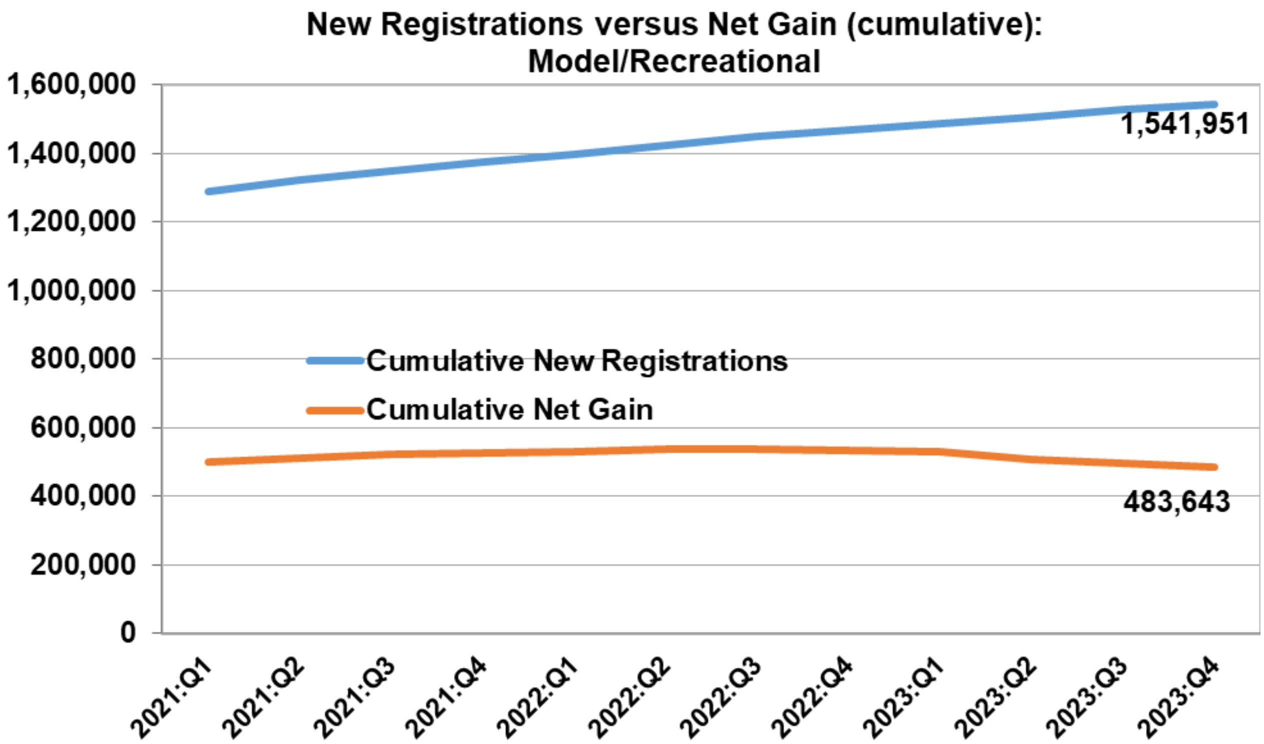
Thus, Net Gain/Loss for August 9, 2023 =

[7] We attribute this methodology of calculations to the UAS Integration Office (AUS), provided internally to facilitate last two year's forecasts.
[8] For cumulative new registration trends, see the final graph preceding this section.

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

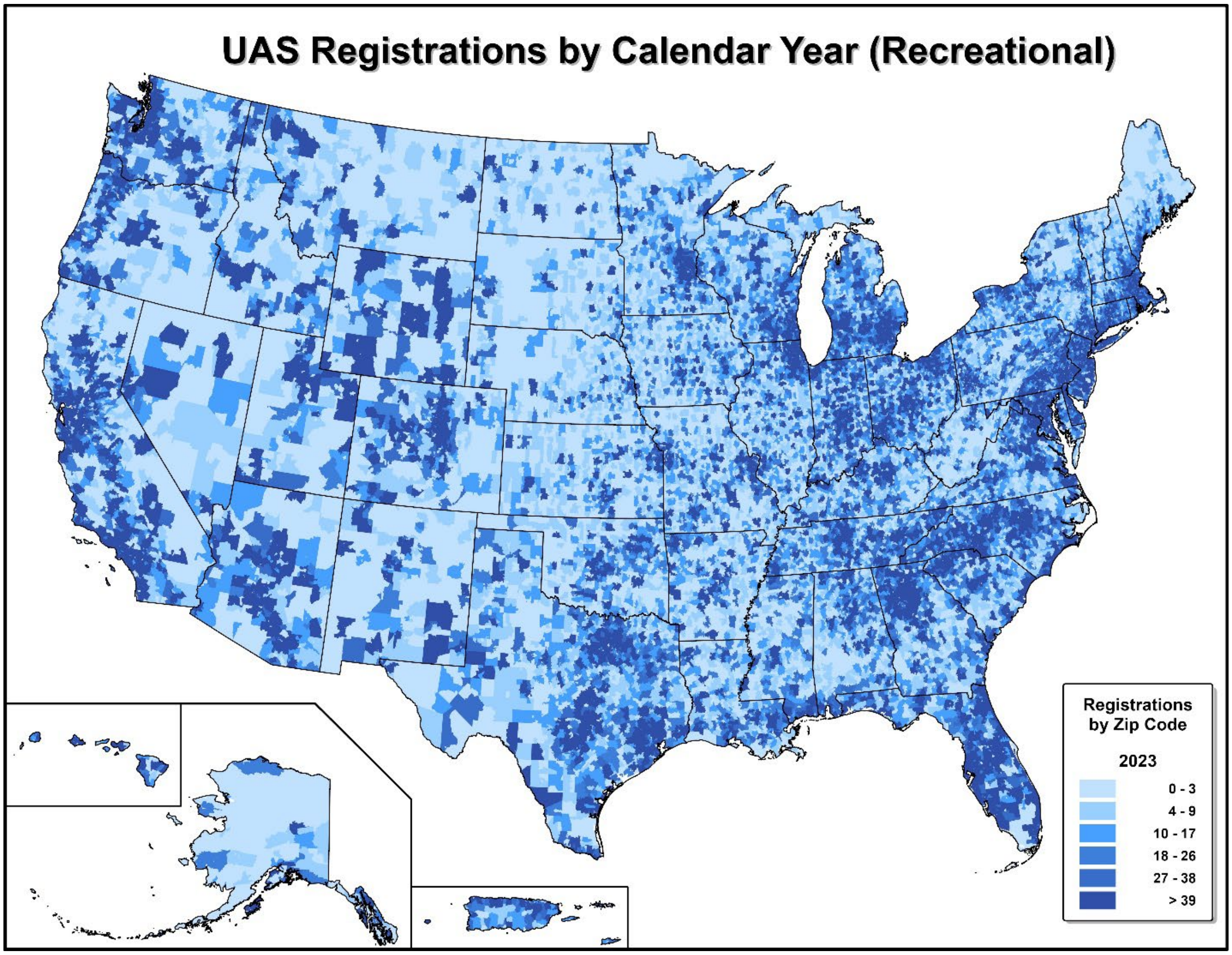
9 X (-1) + 377 X (-1) +
198 X (1) + 105 X (0) +
37 X (+1) = -151

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 2021-2023:[10]



Recreational registration, and thus ownership of small drones, is distributed throughout the country. Using the data available in December 2023, 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.

[10] There are two important aspects making the difference between cumulative new registrations and cumulative net gain: (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 (or slope) 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, 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 projects to understand the possible magnitude of the sector, implications for aircraft that may be used for recreational flying, as well as understanding potential safety impacts of drone 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, previous 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 range, using the calculation of effective or active fleet. With over 1.54 million new recreational operators cumulatively registered as of December 2023, the FAA estimates that there are approximately 1.76 million sUAS in the fleet distinctly identified as recreational aircraft, i.e., equipment is 15% higher than the total new registrations. Comparing with industry sales and other data noted earlier, we conclude that the number of recreational aircraft is almost 14% higher than ownership registration.[11] Applying cumulative net gain/loss calculations from above, the effective/active fleet is estimated to be around 557,300 as of December 2023. This provides us the lower bound of effective/active fleet of recreational small drones in the NAS.

A comparison of last year's data (2022) with this year's (2023) shows the annual growth rate for new registration to be approximately 4.9%, a drop from the year before (6.7%). Nevertheless, still increasing trend, *albeit* lower rate, 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 1.88 million units over the next five years.[12],[13] 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.

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[11] 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.]

[12] 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 aircraft that are presently operating in the system (i.e., low).

[13] As we extend the forecast time period by a year from 2027 to 2028 for rolling 5-year projections, the sector is expected to expand by around 60,000 from what we forecasted last year for 1.8234 million in 2027 to 1.8830 million in 2028. This trend is likely continue due to secular growth in the sector.

This leads to upside possibilities in the forecast of as many as 1.92 million units by 2028. 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, regulatory framework including implementation of remote ID requirements, 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 in the outer years of 2027-2028. A forecast base (i.e., likely), together with high and low scenarios, is provided in the table below:[14]

	Total Recreation/Model Fleet (Million sUAS units)			
	Calendar Year	**Low***	**Base****	**High****
Historical	2023	0.5573	1.7768	1.7768
Forecast	2024	0.5557	1.8264	1.8308
	2025	0.5832	1.8470	1.8674
	2026	0.6092	1.8673	1.8913
	2027	0.6213	1.8787	1.9075
	2028	0.6288	1.8830	1.9208
'*': 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 1.7502 million drones in 2023 in base case (i.e., new registrations), a growth rate exceeding 3.7% from the year before (2022). Actual data for 2023 came in higher by 26,613 units with around 1.7768 million units accounted for by the end of 2023. Thus, our-forecast of recreational small drones last year undershot by around -1.50% for 2023, (or 1.7768 million actual aircraft in 2023 vs 1.7502 million aircraft projected last year). In contrast, our last year's forecast of low scenario stood at around 620,472 for 2023. In reality, actual data came to be 557,300 (or around 63,000 lower). Thus, our forecast of lower range last year overshot actual by over 11%.

[14] 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 2023 is markedly different than the baseline and high scenario for the same year.

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 this year of 2023; 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) maintain its peak with average or trend growth over the next 5 years, from the present 1.78 million units now to approximately 1.88 million units by 2028 thus attaining cumulative annual growth rate of 1.2% during 2023-2028. During the last year, it was reported to be 1.6% for 2022-2027.

Following somewhat different growth trajectory than the base or high growth, there will likely be approximately 628,800 active/effective small drones (or, 71,500 more than what was observed during 2023) over the next five years in 2028, which is now the low forecast for recreational/model small drones. This ensures a cumulative annual growth rate of 2.4% during 2023-2028. Active/effective fleet count is derived and projected based on the net gain/loss calculation derived from using five underlying components discussed above; hence, the rate influencing lower forecasts growth is different than the base forecast which is derived using new registrations. The high scenario, on the other hand, may reach as high as 1.92 million units (or, 1.6% 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 continued new registrations, *albeit* at a slower rate, by recreational flyers observed during 2023 and extension of the forecast projection by a year. The increased new registration trend, in part driven by COVID-19, may or may not continue in the longer run.[15] In comparison, low side forecasts assume the present trend in renewals combined with new registration followed by similar expiry and cancellations trends. 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 active in the NAS.

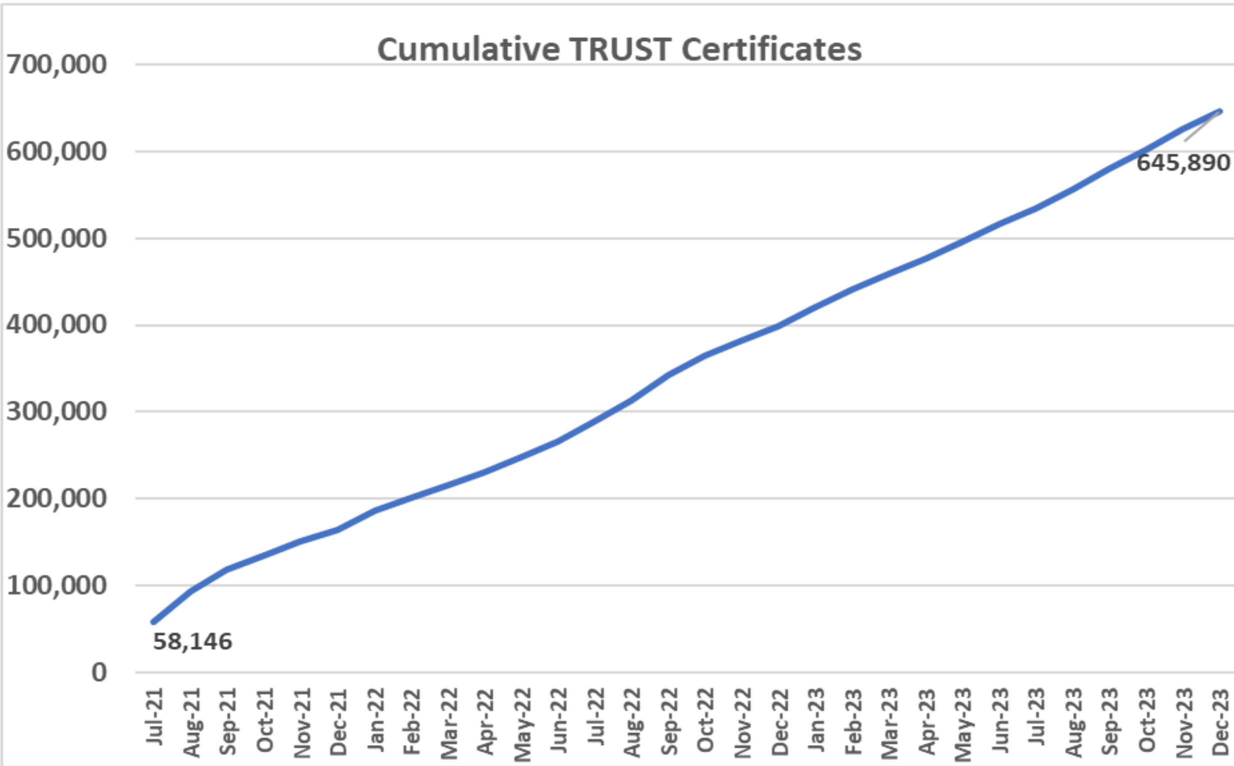
The Recreational UAS Safety Test (TRUST)

Under the most recent (2018) reauthorization bill,[16] new requirements for recreational pilots have been introduced [See P.L. 115-254

[15] It is quite likely that many users were 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.

[16] See https://bit.ly/2pAYYxG.

– The exception for limited recreational operations of unmanned aircraft]. TRUST is the safety test for recreational/model small drone operators. It provides training 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.[17] By December 2023, around 646,000 recreational flyers completed TRUST certification subsequent to its inception in June and data collection from July 2021.[18]



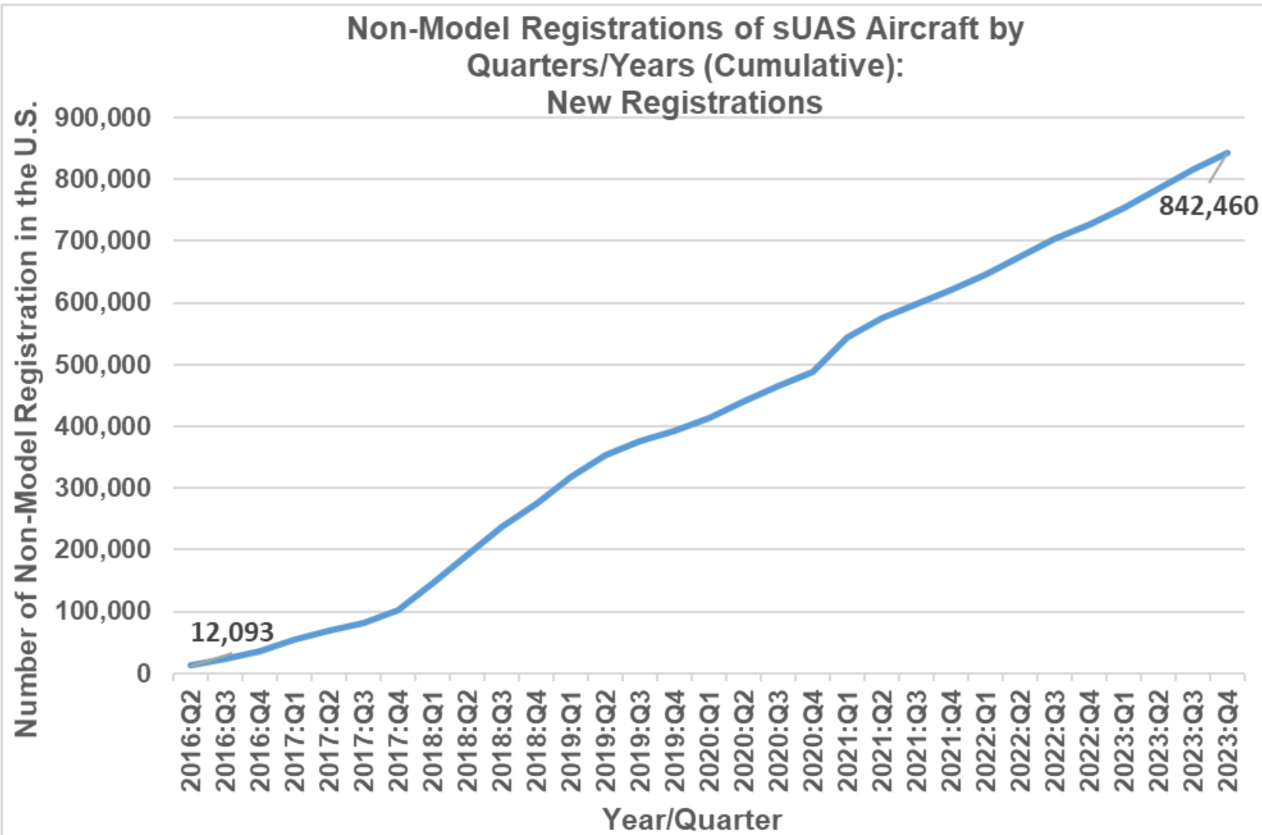
Trends in Commercial/Non-Model Aircraft and Forecasts Using Registrations vs. Effective/Active Fleet

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 2023, more

[17] See https://bit.ly/3K3MF5Q for more details.

[18] It is important to note here that with 645,890 TRUST certificates already issued is over 34% of effective or active model/recreational registration of sUAS (i.e., 483,643). Hence, TRUST certificate holders are presently over 162,000 more than effective/active recreational registrants. It is not quite evident why the numbers are higher than registration except that it is quite likely that owners of drones that weigh less than 0.55 lbs (250 gms) are also completing TRUST certification. According to present rule, all drones must be registered, except those that weigh 0.55 pounds or less (less than 250 grams). These are flown under the Exception for Limited Recreational Operations [see http://tinyurl.com/2y5zn6xd] for more details. It is also likely that some STEM programs [see https://tinyurl.com/yn2fm56n] include having students complete TRUST before operating drones owned by the STEM program leader. That will also contribute to difference in numbers.

than 115,000 commercial operators registered their new equipment. In comparison, more than 105,000 commercial operators registered new equipment during the same period the year before in 2022. The pace of monthly registration, around 9,627, is higher than monthly registrations during 2022 which stood at 8,750 which was higher than monthly registrations during 2021 at approximately 8,500. The pace of new registrations is picking up speed slightly in comparison with 2021 and prior years. 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 over 842,000 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 year of 2022, average monthly registration again jumped by 250 to around 8,750 while during the last year of 2023, this further jumped to 9,627 or by 877 from the year before. The commercial small drone sector is dynamic and appears to be at an inflection point, as evident from the monthly registrations, 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 the 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.[19] Beginning in April 2021, routine nightly operations were approved under the conditions of the remote pilot in command (RPIC) completing the updated 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.[20] Upon adjudicating numerous comments from stakeholders, the final rule[21] 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 (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 became effective on September 16, 2022 as well. Finally, all drone pilots had to meet the operating requirements of part 89 by September, 2023.[22] For most operators this means flying a standard Remote ID drone, equipping with a broadcast module, or flying at a FRIA. However, the FAA acknowledged that some drone pilots were not able to be ready to comply because of limited availability of broadcast modules in time and lack of FRIAs. Hence, FAA extended enforcement of RID implementation until March 16, 2024.[23]

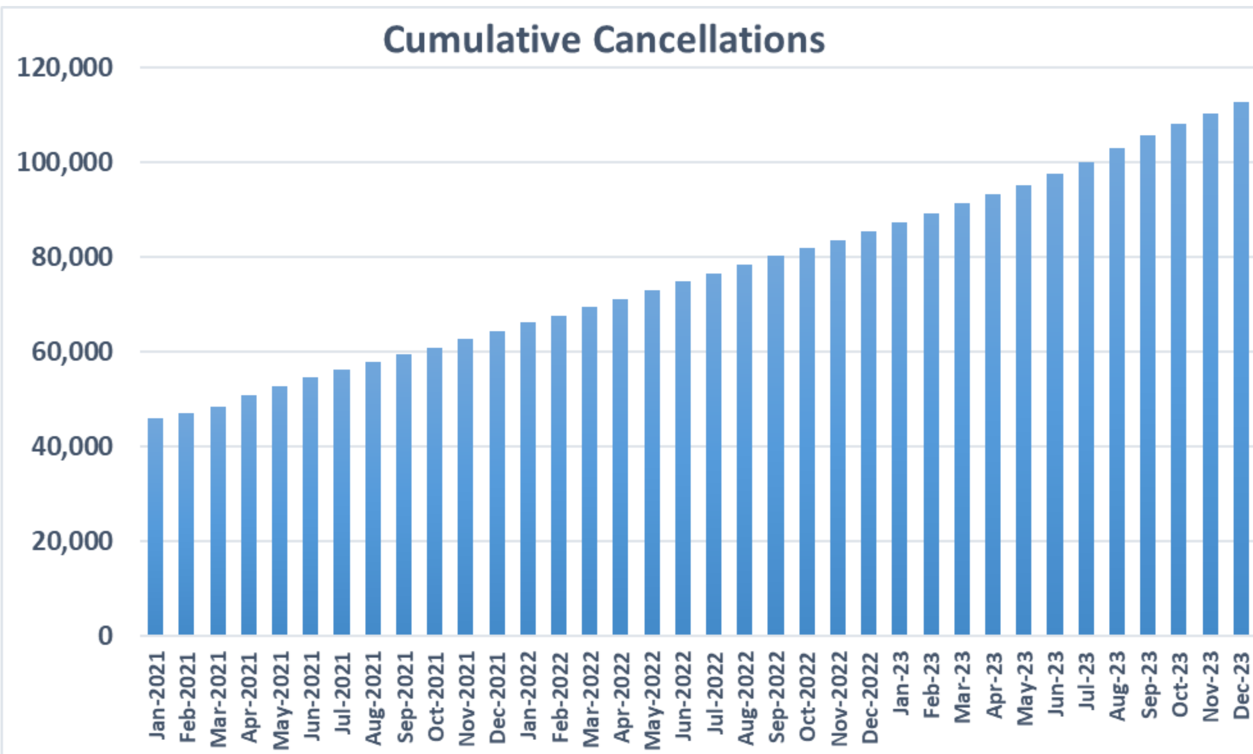
Together, these rules provide much-needed regulatory clarity and reduce the need for waivers under Part 107. With enhancement of operational efficiencies under increasingly well-defined concepts of operations (CONOPS)—which ensures safety and transparent information flow across the community—more and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

[19] See https://bit.ly/3ZGumJC for more details.
[20] See https://bit.ly/3K9wSCv.
[21] See https://bit.ly/3MfupZS for more details.
[22] See https://bit.ly/3KaZQln for more details.
[23] See bit.ly/3RICM2x. For public access to RID compliance, see https://uasdoc.faa.gov/listDocs

operational information, including registration, authorization, and accident report logs the FAADroneZone has helped further facilitate this growth.[24]

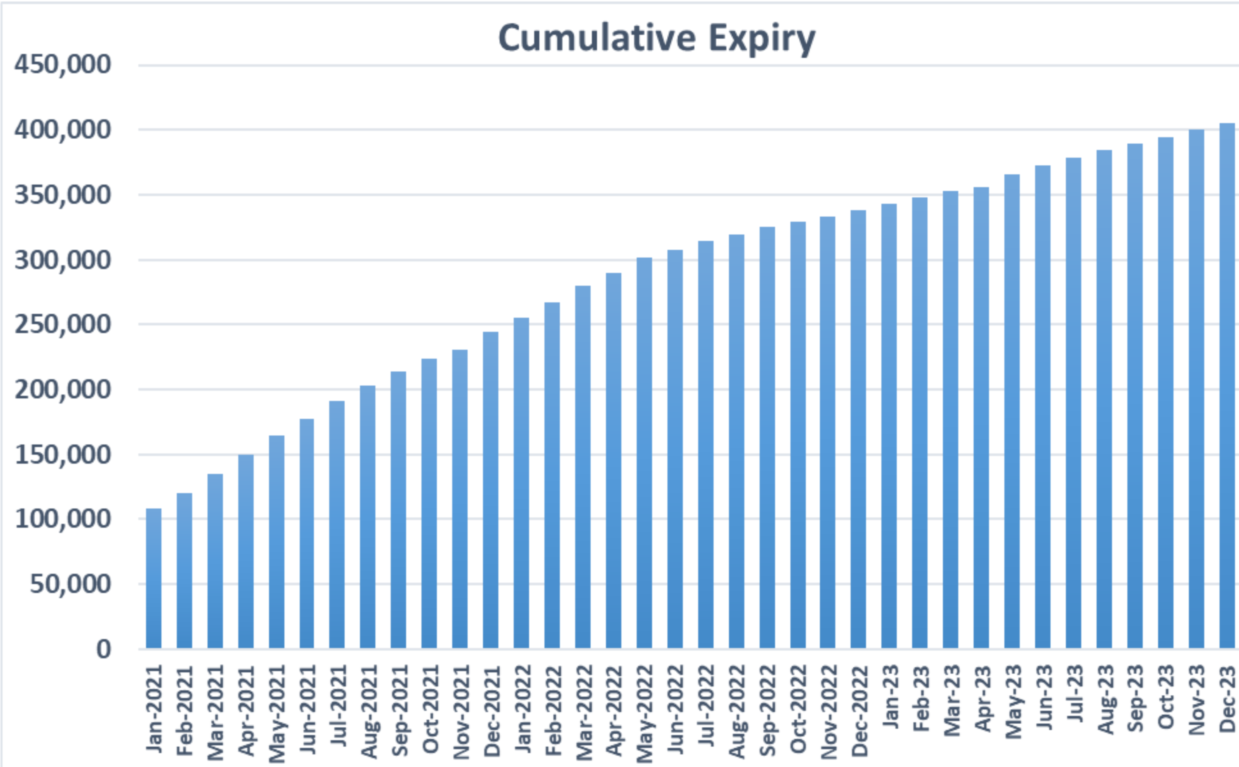
As noted in the preceding section, the beginning of the registration renewal afforded the FAA an opportunity to review Part 107 data; duplicates and unnecessary registrations were removed, and the registration database was made cleaner and more compact. As in the case of recreational/model aircraft, 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 that, prior to having access to these five elements, forecasts in the past were based only on new registration trends.

An average of 99,527 cancellations per month, on a cumulative basis, were reported during January – December 2023, as shown below. The trend in cumulative cancellations went up by almost 24,000 from the year before. This is an average of approximately 2,280 (1,743 the year before) new cancellations for each month of 2023.

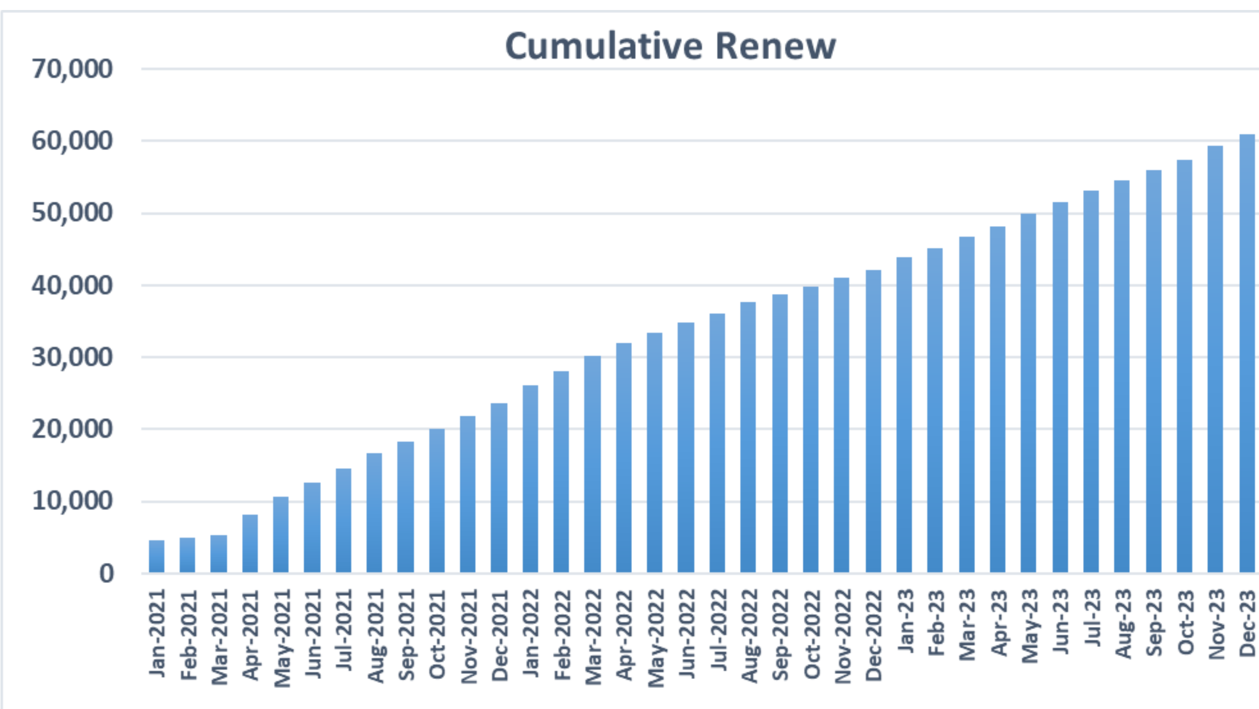


An average of over 374,000 expirations per month was reported (305,000 the year before) on a cumulative basis between January–December 2023 as shown below. This equals approximately 5,620 new average expiries for each month during January– December 2023:

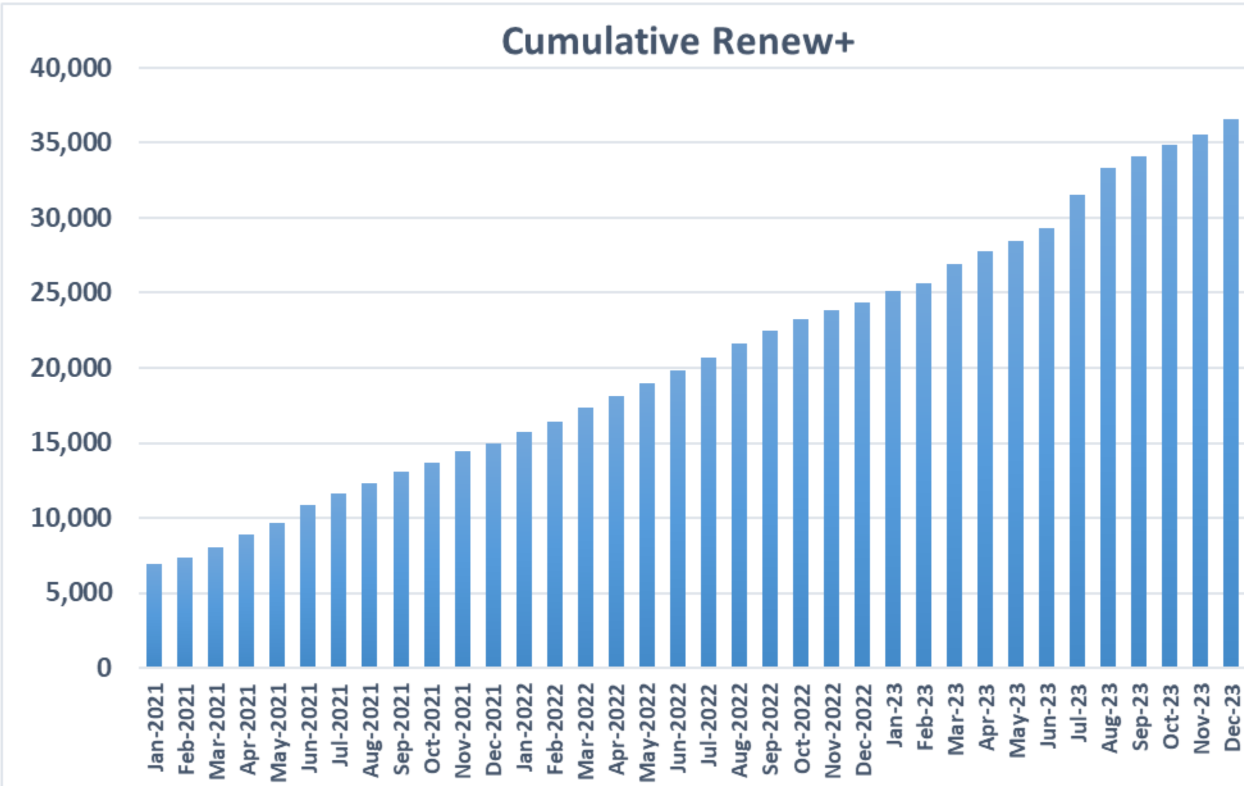
[24] See https://faadronezone.faa.gov/#/.



Renew or re-registration prior to expiry date continue to accelerate, on average, to over 52,000 (35,000/month the year before) on a cumulative basis (or a one and half time increase from the year before) during January–December 2023 (or 1,565 new average renewals):



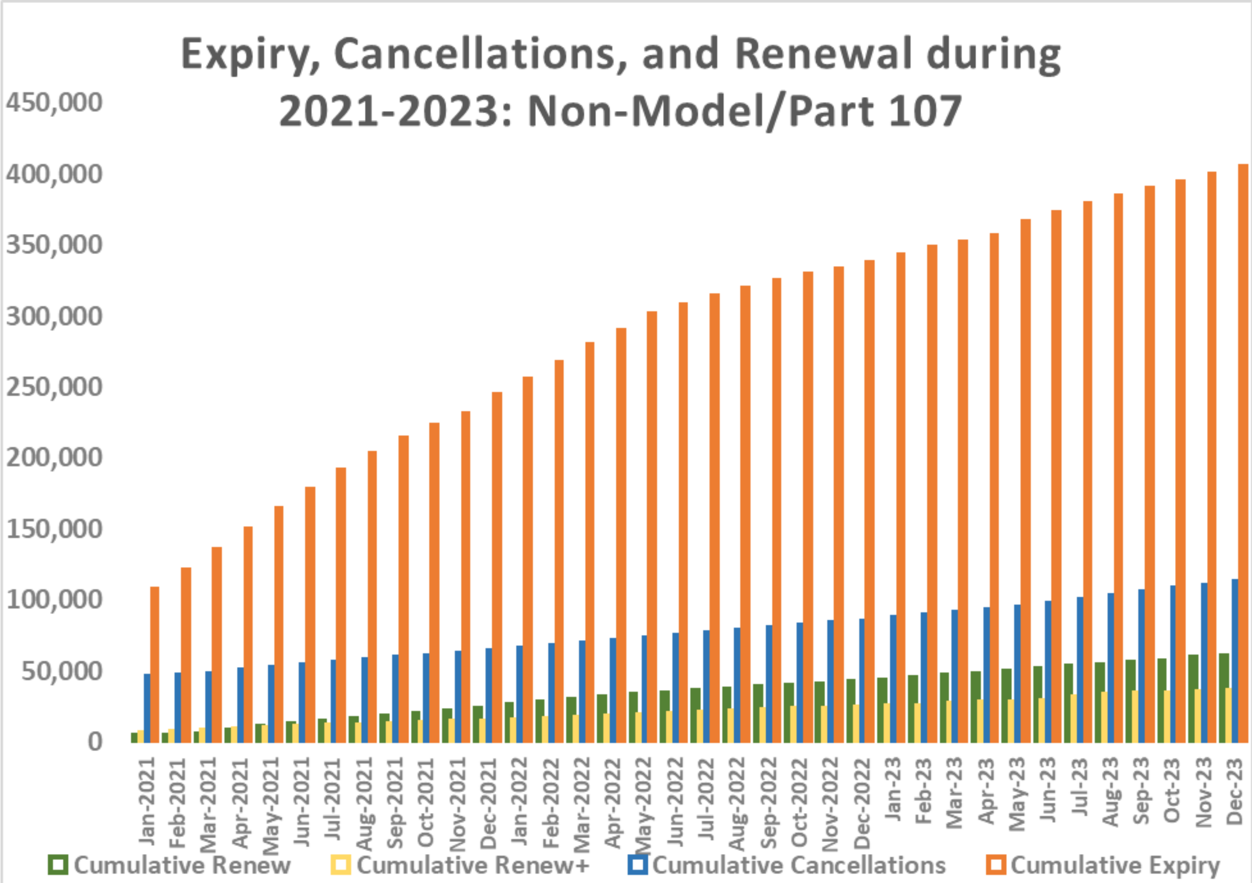
Similar to renewals, "Renew+" (i.e., re-registrations after expiry), logged at a rate much higher than last year to an average 30,772 during the months of January-December, 2023 (compared to 20,216/ month on a cumulative basis the year before). This is an average of 1,016 new Renew+ each month during January–December 2023 (784 from year before), as reported below:



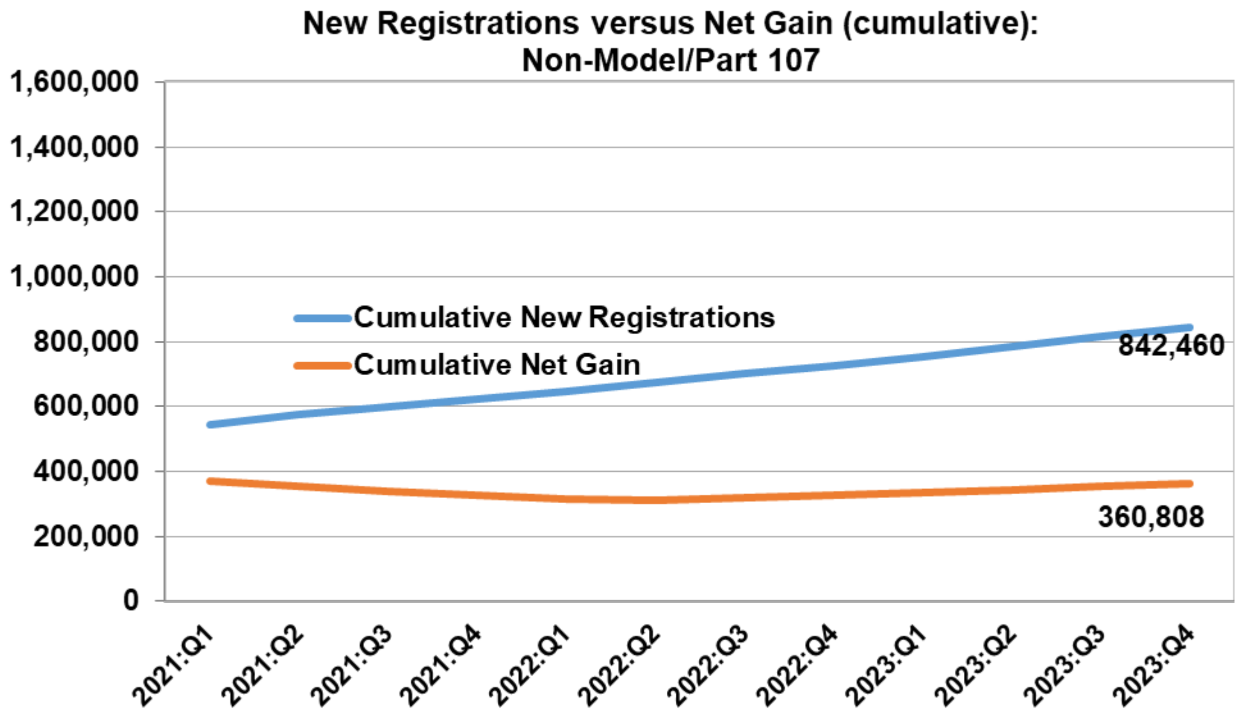
As in the case of recreational/model registrations, calculating active/effective registrations for a particular day requires calculating the "net gain/loss" of registrations for each preceding day and adding them with the particular day (i.e. calculating the running sum).

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

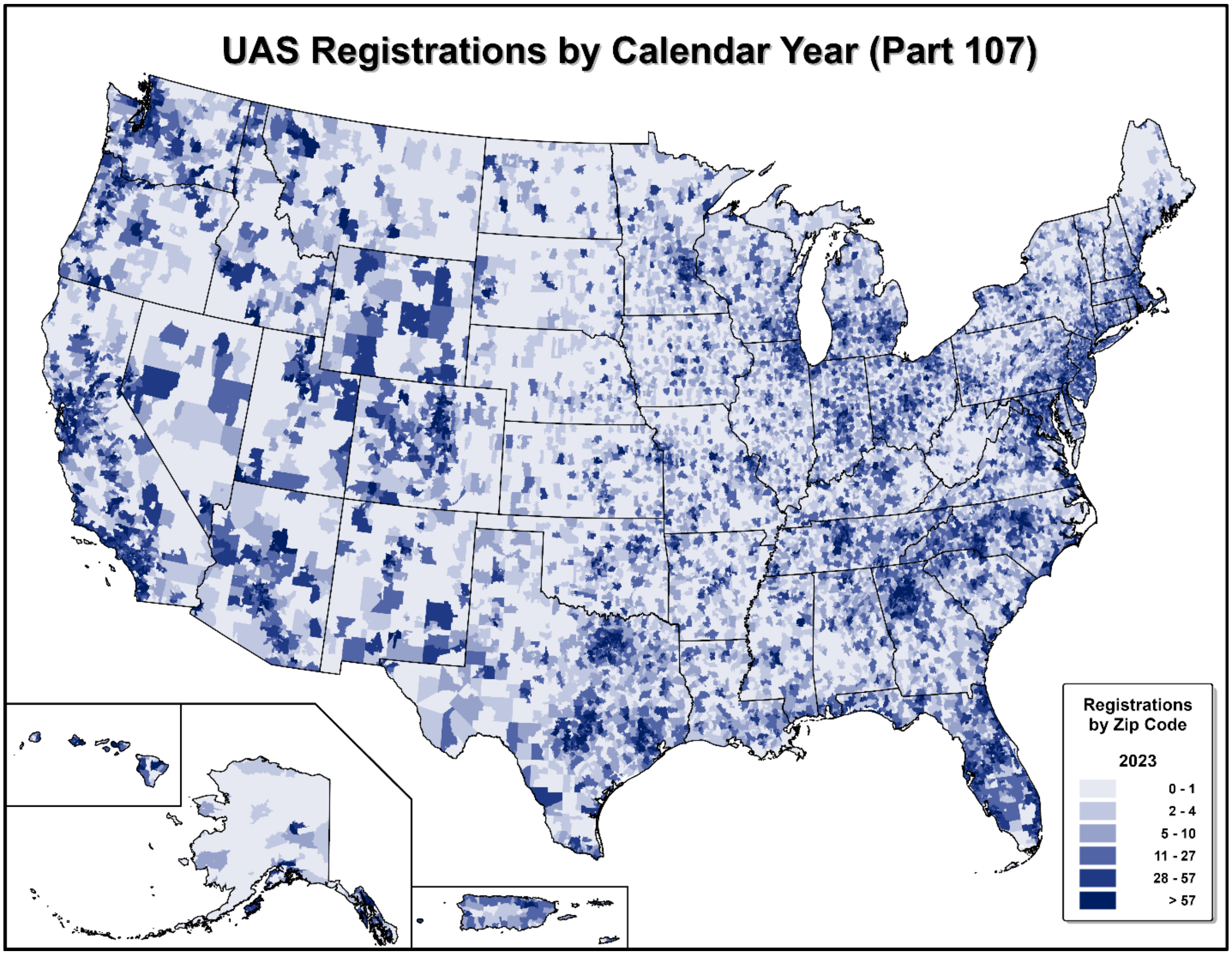
A summary of the above 4 charts is provided below to relate the relative contributions of cancellations, expiry, renew and renew+:



A comparison chart capturing the difference between cumulative new registrations vs. effective/active registrations using net gain/loss for Part 107 registration is provided 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 2023) 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.



Last year, the FAA forecasted that the commercial drone sector would include over 805,000 small drones in 2023 in base case, a growth rate exceeding 11% over the year before (2022). Actual data came in over 842,000 aircraft by the end of 2023. Our forecast of commercial small drones last year thus undershot (around -4.4%) for 2023 (or 842,460 actual aircraft vs 805,448 projected aircraft). In low case, FAA forecasted last year 349,000 units to be effective/active for the year 2023; but in reality, the number came to be around 361,000 thus undershooting the lower case by -3.3%. 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)				
Calendar Year		**Low***	**Base****	**High****
Historical	2023	361	842	842
Forecast				
	2024	369	951	960
	2025	371	1032	1050
	2026	372	1083	1113
	2027	373	1110	1152
	2028	374	1122	1176
'*': effective/active fleet counts.				
'**': new registration counts based 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 FAA-sponsored research..[25] 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) exceed a million mark with around 1.122 million by 2028. This is 1.33 times larger than the current number of new commercial small drones.[26]

Using low or effective/active fleet, the FAA forecasts an expansion of the small drone fleet by 12,800, 1.03 times larger than the currently calculated effective/active fleet of around 361,000 units.[27] 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 makes use of 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 $1,500.[28] The professional grade, on the other hand, is typically priced above US $10,000 with an average unit price assumed to be around $30,000.[29] For both

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

[26] Last year, the ratio of end-year forecast to base-year forecast was 1.31-times. That is, the FAA forecasted end-year to be 1.31 time base year's (2022) numbers in 5-year (2027). Higher forecasts are often the result of improved regulatory environments, as noted below, and environments following the process of rule-making evaluation (See fn. #30-33 for these).

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

[28]See https://tinyurl.com/5dswkz6b for more details.

[29] 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 $30,000.

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.

At present, the sector has numerous uses, primary among them is the general photography and real estate. While real estate draws chiefly from the Part 107 registrants, general photographers are often drawn from recreational registrations. Despite this difficulty in using strict definition including the uses of types of vehicles, it is instructive to note the distribution of types of industries/businesses that Part 107 users primarily, and to some extent, recreational users are involved in as reported by Teal Group[30]:

US Commercial Market (Units)		
Units (Air Vehicles) in 2023	Total	Percent-ages
Construction	29,000	3.96%
Energy	22,220	3.03%
Agriculture	43,000	5.86%
Communications	300	0.04%
Insurance	10,250	1.40%
Gen. Photography/Real Estate	600,300	81.88%
Other Industrial Inspection	7,600	1.04%
Entertainment	20,000	2.73%
Delivery	500	0.07%
Total	733,170	100.00%

Earlier, we accounted for around 361,000 Part 107 registrations and equipment or air vehicles in 2023, the table above shows total number of vehicles in excess of 733,000. These differences are likely the result of different definitions used in accounting for vehicles in addition to many recreational users accounted for as commercial/Part 107 activities. Nevertheless, using the above table, we notice that over 82% of total commercial users are classified into the category of general photography and real estate. This is the direct result of both commercial and recreational users' early adoption of sUAS. Flexibility of using recreational drones into commercial photography, such as weddings, sports, personal property inspections, customized photo events, etc., allowed first entrants into this market space. Following this outsized market share, agriculture (6%), construction (4%), energy (3%), entertainment (3%), industrial inspection and insurance, each with 1% market shares, account for the rest.

Delivery services, primarily last-mile delivery, is rather small with 500 vehicles [see Table above] but expected great potentials once

30 https://tinyurl.com/5dswkz6b

the economics and regulatory issues have been appropriately addressed over the next few years. In the interim, to ease the regulatory environment, the FAA issued numerous summary grants[31] to the UAS delivery industry in recent times. The FAA used Exemption No. 18339D[32], the full grant FAA provided to UPS Flight Forward in September 2023, in conjunction with full grants for Phoenix Air Unmanned, LLC and uAvionix Corporation. Since then, the FAA issued summary grants to Causey Aviation Unmanned, Inc, Zipline and Amazon Prime Air as well. The latest recipient of a summary grant for true beyond visual line of sight (BVLOS) without any visual observers on the ground is Wing under the same exemption from before. With these summary grants, Wing is serving another Walmart location in Lewisville in addition to its original, and now for several months of service in Frisco, in the greater Dallas-Fort Worth area of Texas.

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 rules involving operations over people; flying at night, remote ID, and future Normalizing UAS Beyond Visual Line of Sight Operations rulemaking[33]), 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 delivery packages, routine blood delivery to hospitals, and search-and-rescue operations) that are somewhat latent and in the experimental stages 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 (unchanged from last year). 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 thus determined by the combined effect of both positive and negative factors; and presently calculated to be approximately 0.7%. This is much smaller than both base (5.9%) and

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[31] Summary grants are a tool the FAA uses in all exemption areas, not just UAS. In this context, summary grants can be thought of as a bridge towards the wide and true BVLOS operations which would likely accelerate drone use in numerous sectors noted earlier. Early signs are indicating this may be true as Walmart announced early in January, 2024 the expansion of its drone operations in the Dallas-Ft. Worth area using existing service partners such as Zipline and Wing. This will likely expand the aerial coverage to 1.8 million additional households, a landmark development in scaling of aerial deliveries across the US [See http://tinyurl.com/3crfuzjw].

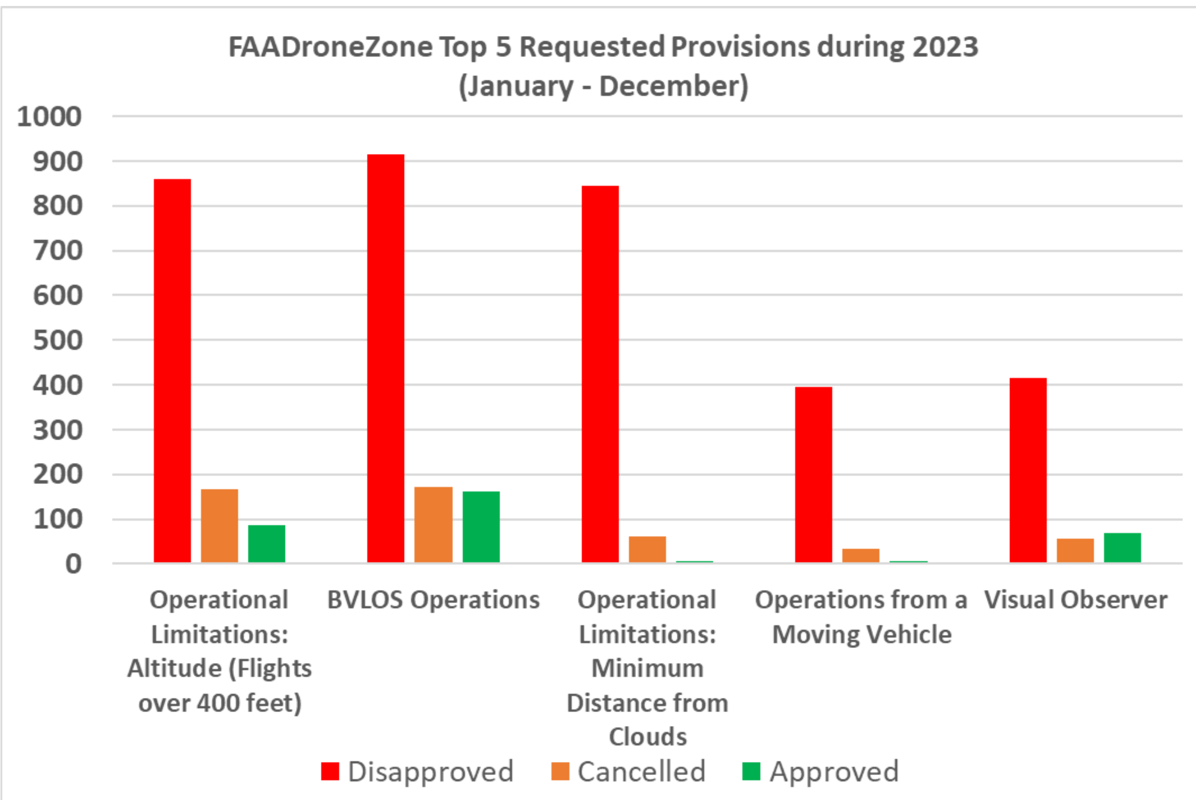
[32] See https://www.faa.gov/media/70421 for more details.

[33] See https://tinyurl.com/2fmxzaee for more details.

high scenarios (6.9%) and this is because effective/active count is driven to catch up with the new registrations trend.[34][35]

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 work to begin implementing the UAS traffic management system (UTM) ecosystem,[36] successful completion of the UAS Integration Pilot Program (IPP),[37] and continuation in BEYOND.[38]

As Part 107 sub-provisions are relaxed, it is important to identify trends in commercial small drone use 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 top waiver requests (i.e., approved, disapproved or denied, and cancelled due to lack of information primarily or withdrawn) aggregated for January-December 2023 is shown in the chart below:



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

[34] Findings from our survey, discussed last year and this year in later section, also support this observation.
[35] See prior footnotes for similar explanation pertaining to effective/active count for recreational registration.
[36] See https://bit.ly/3KucgX4
[37] See https://bit.ly/2O4tzPP for more details.
[38] See https://bit.ly/3nKAOlK. We provided a detailed analysis of BEYOND program in last year's document.

extent, for numerous other operations involving BVLOS, flying over 400' AGL, etc. BVLOS waiver requests (around 30% of total requests, twice from the year before) and limitations on altitude (around 26% of total requests; an increase of 12% from last year) account for almost 56% of all waiver requests submitted. Waiver requests are granted at a rate of 8% and 13% (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,[39] 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[40] or over people under certain conditions,[41] the Agency is turning its focus to long term solutions that will eventually enable routine, scalable BVLOS fights without waivers.[42] 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.

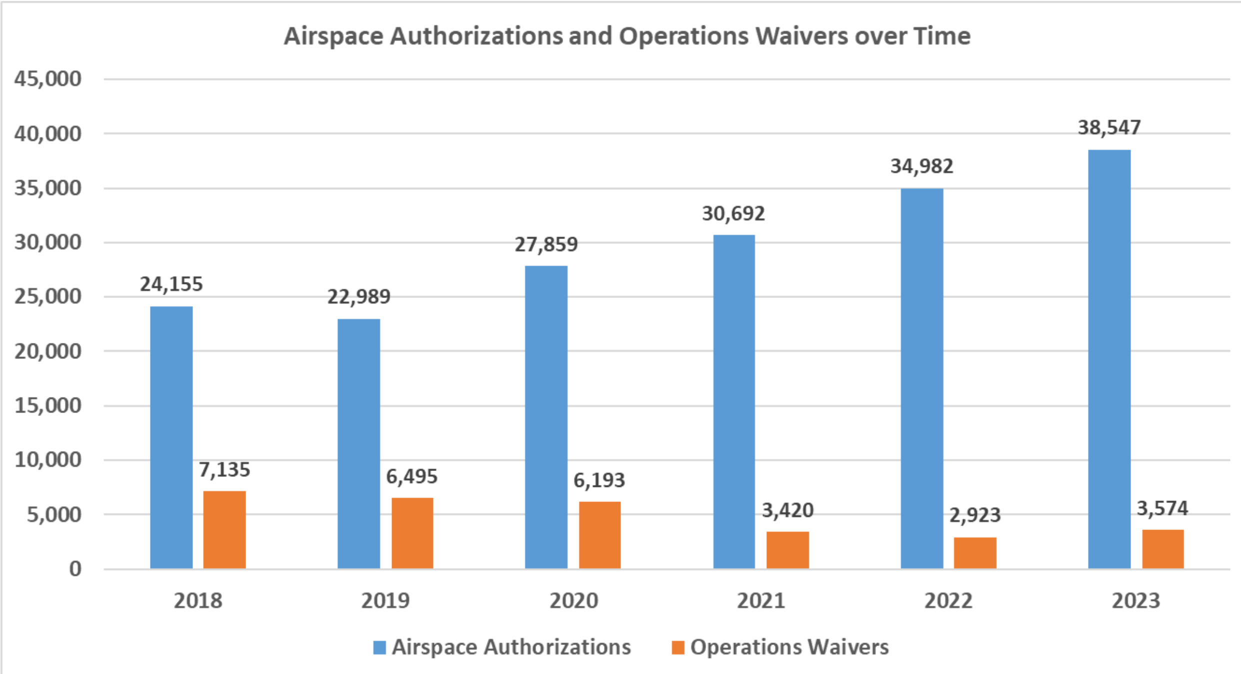
Airspace authorizations have been growing over time as shown in the chart below. While airspace authorizations have been growing consistently since 2019, at an average annual rate of around 10%, operations waivers have been declining over the years with an average annualized growth rate of -13%. Interesting to note that operations waivers ticked up during the last year (2023) after declining for the entire period of 2018-2022. Nearly 60% of airspace authorizations and waiver requests have been approved for controlled airspace at the end of December 2023.

[39] 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].

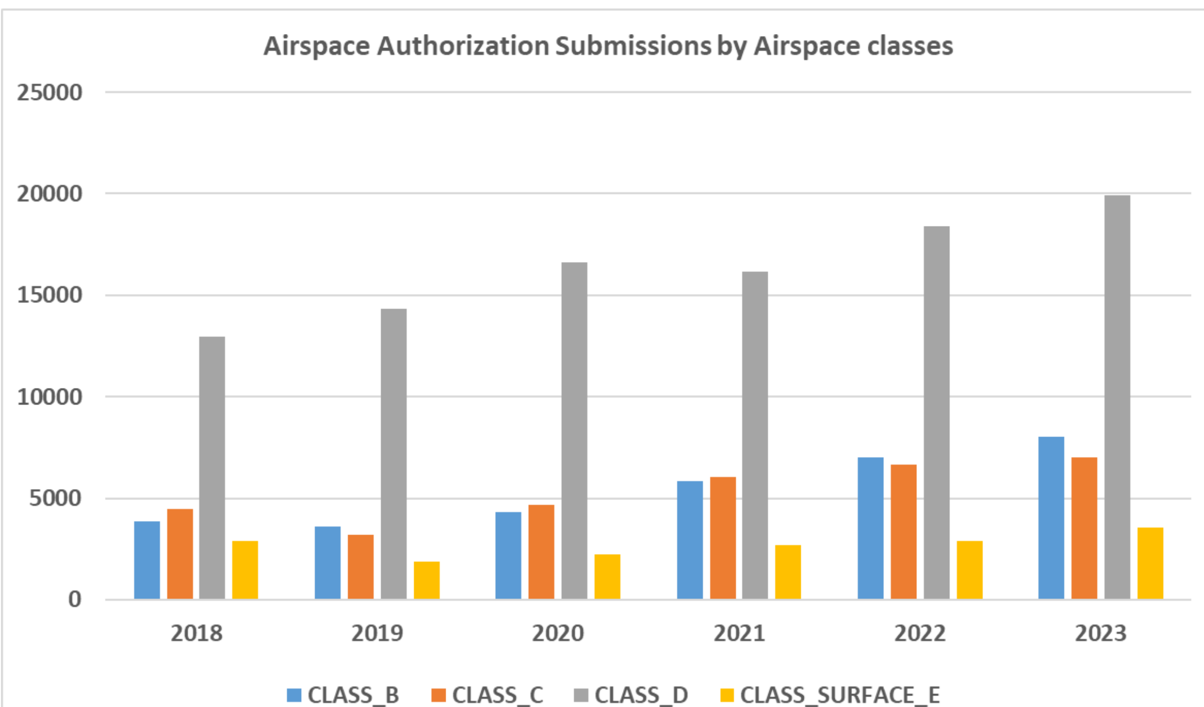
[40] See § 107.29. An operation at night was defined as an operation conducted between the end of evening civil twilight and the beginning of morning civil twilight, as published in the Air Almanac, converted to local time (ibid).

[41] 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.

[42] 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]

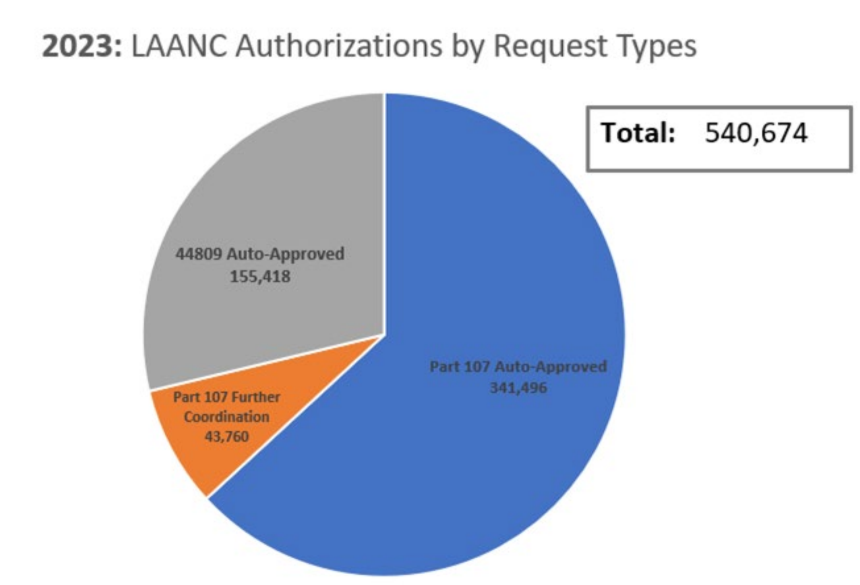


While over half continue to be for Class D airspace (i.e., smaller airports with control towers), other classes were also requested, granted and regularly flown as reported in the chart below:



Finally, LAANC has been routinely providing auto-approval since its inception in May 2017, and now covers 726 airports[43] with UAS Facility Maps or UASFM[44] enabled at 740 airports.

Last year, LAANC provided almost half a million approvals: 341,496 auto-approvals for airspace access requests from Part 107 users; and 155,418 requests from recreational operators as defined by 49 U.S.C. §44809[45] and sending 43,760 for further coordination.[46] Approvals thus total 540,674, over 41,000 more since this time last year. LAANC authorizations are facilitated using UASFM that provide maximum allowed altitudes around airports where the FAA may authorize Part 107 UAS operations without additional safety analysis.[47] The UAS facility maps are used to inform requests for Part 107 airspace authorizations and waivers in controlled airspace.



2023 Survey and Preliminary Results

The FAA has strived to develop a better understanding of the flight characteristics and operations of UAS across the United States. Unlike commercial aviation, which has statutory reporting requirements, UAS 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 UAS, which has hindered the FAA efforts to effectively integrate UAS into the NAS.

To improve the FAA's understanding of UAS activities, following on earlier similar effort, the FAA has developed and conducted a survey of UAS operators. This Office of Management and Budget (OMB) approved survey information collection started with a baseline and pre-tests for UAS activities in 2021 and has continued with the survey for UAS activity in 2022 and 2023. The survey design is a stratified, random sample of UAS

43 See http://tinyurl.com/yckey35h
44 See https://bit.ly/3KwWOtj.
45 §44809 is strictly for recreational uses. See https://bit.ly/3zvW6pL.
46 Activity reported below is for the calendar year of 2022: January 1-December 2022.
47 See https://bit.ly/3K2hFmA.

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 UAS and the Part 107 registries.[48] A total 60,162 invitations were sent to UAS registrants: 41,001 recreational registrants and 19,161 Part 107 registrants, located in over 2,100 U.S. counties and constituting roughly 30% of active UAS registrants.[49] The survey for 2023 UAS activity was opened on December 14th, 2023 and closed on February 16th, 2024. Follow-up reminder emails were sent out periodically to those who had not yet responded up until the final week of the 2023 survey.

Overall, 26.2% of invited registrants responded to the 2023 survey. The response rate varied marginally by registry. Recreational registrants were slightly more likely to respond with a 27% response rate than Part 107 registrants with a 23% response rate. This difference in responses rate by registration is consistent with the 2022 survey and the 2021 survey baseline.[50] Of the invited registrants who did not respond, 4.9% had unreachable email addresses and an additional 5.4% had opted out of receiving emails from Survey Monkey while the reasons for the remainder of the non-responses are unknown.[51]

The survey of UAS operators used a questionnaire distributed by Survey Monkey to collect responses from selected, registered UAS operators.[52] The questionnaire consisted of as few as 6 questions or as many as 40 questions based on the respondents' answers and the registry from which they were recruited.[53] Some questions had multiple response options and the average time to complete the survey was approximately 10 minutes. Given that many operators use their UAS for several purposes, selected Part 107 registrants reported primarily about their

[48] As noted earlier, 49 U.S. Code § 44809 requires recreational UAS 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.

[49] 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.

[50] 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.

[51] 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.

[52] 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 UAS operators, an internet-based questionnaire, such as Survey Monkey, was best suited for this population. More information is available via survey supplement.

[53] The language used in the survey was tailored to recreational and nonrecreational operators. Most questions provided for optional responses, required responses were rare. Periodically the survey asked an open-ended question soliciting general feedback about the survey and specific questions. Some questions were unique to specific groups such as emergency responders. More information is available in survey supplement.

non-recreational activity while selected recreational registrants reported on their 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.[54] Of those that accessed the survey, 94% agreed to participate, 2.9% opted out of the survey for 2023, and 3.3% requested that the FAA permanently remove them from the FAA's survey list.

The survey contained a self-report question on the type of UAS operator the respondent considered themselves. Respondents were given the multiple-selection options of; (a) commercial, business, or pilot for hire; (b) emergency response, public safety, or law enforcement; (c) other government (non-emergency); (d) university, research institution, or non-profit; (e) recreational or hobby: drone; (f) recreational or hobby: model aircraft; and (g) a fill-in "other" category. The distinction between recreational drone operator and recreational model aircraft operator was added in the 2023 survey in a response to feedback and data from the 2022 survey. For respondents from the recreational registry, 98.3% self-identified as recreational operators, with 72.3% identifying as drone operators and 40.7% identifying as model aircraft operators. Despite 14.8% of respondents identifying as both recreational drone and model aircraft operators, 57.5% identified as drone and not model aircraft operators, and 25.4% identified as model aircraft and not drone operators. A minority of 1.7% of operators did not self-identify as recreational and instead self-identified with a use better suited for Part 107 or selected "other".

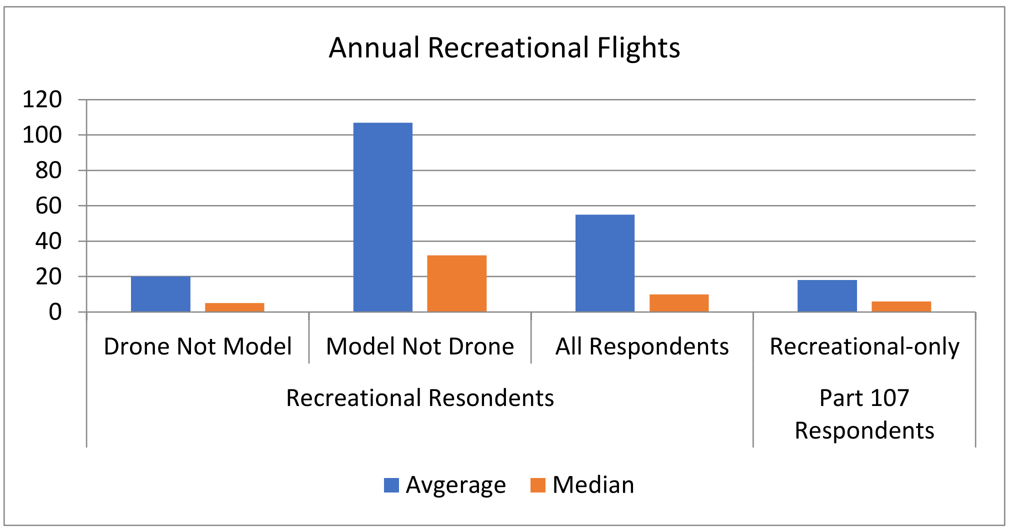
For respondents from the Part 107 registry who self-identified, almost one half of respondents (48.4%) identified exclusively as recreational operators. Of those 91.0% self-identified only as recreational drone operators, 4.1% only as recreational model aircraft operators, and 4.9% as both. Approximately one fifth (20.3%) of Part 107 respondents self-identified with at least one recreational and one non-recreational category and just under one third (31.3%) self-identified exclusively as non-recreational operators. A minority of respondents (1.2%) selected only the "other" category. Of those identifying as any non-recreational operator category, 74.2% reported operating their UAS for commercial, business, or pilot for hire reasons, 21.2% for emergency response, public safety, or law enforcement, 11.0% for other government (non-emergency) purposes, and 12.5% for university, research institution, or non-profit purposes. The self-identification question suggests that the vast majority of UAS operators who register in the recreational registry are using their UAS for personal enjoyment. However, Part 107 registrants have more diverse uses for their UAS. With nearly one half of Part 107 registrants using their UAS for personal enjoyment, defining all of Part 107 operators as non-recreational or non-hobby is likely not accurate.

All respondents regardless of the registry in which they registered were asked about the average number of flights, defined as a take-off and a subsequent landing. Respondents

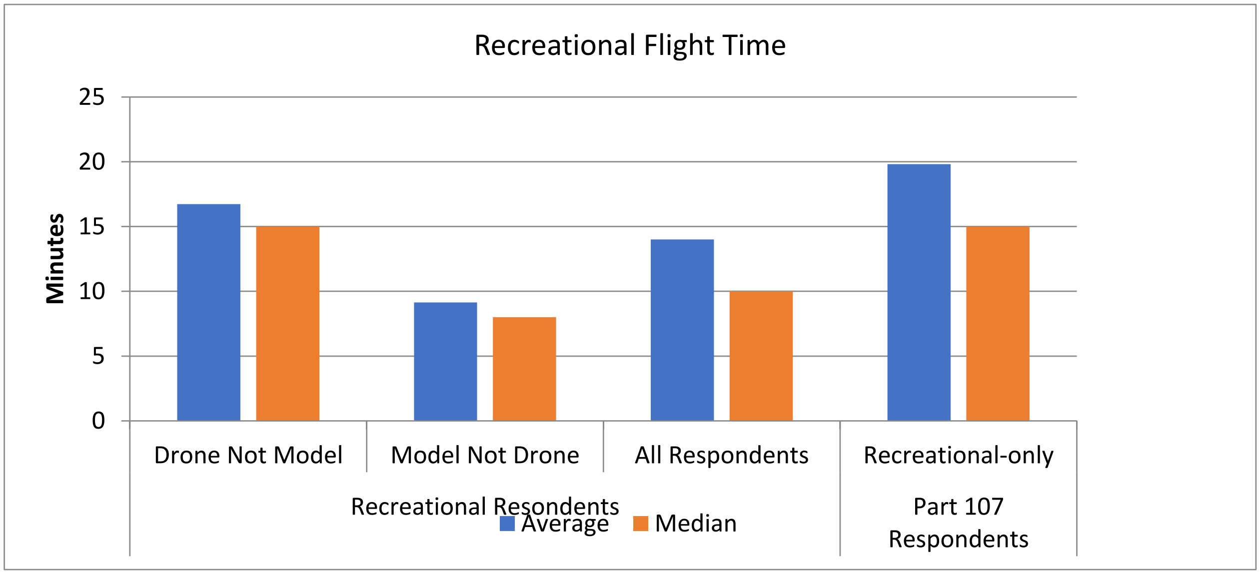
[54] Invited registrants had several means of opting out of the survey, including opting out through Survey Monkey, opting out of the current year's survey in the questionnaire, or removing their email from the FAA survey list in the questionnaire. More information is available in survey supplement.

from the recreational registry reported an average of 54.9 flights a year across the United States. However, the median was only 10 flights per year; suggesting that many recreational operators are using their UAS around once a month while a smaller group of enthusiasts are operating much more frequently.

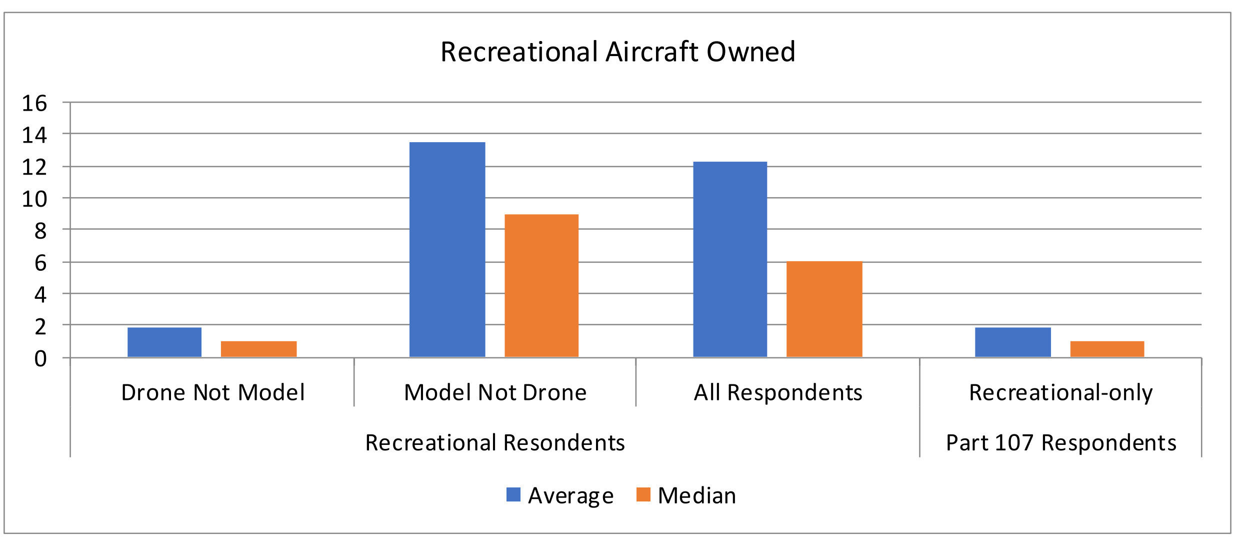
All respondents were asked about the average duration of each flight. With respect to the respondents from the recreational registry the average duration of each flight was 14.0 minutes, with a median duration of 10 minutes.[55] They reported an average of over 6 UAS per operator with the median operator owning 2 aircraft. Respondents from the recreational registry who self-identified as a drone operator and not a model aircraft operator reported an average of 1.7 aircraft owned with 1.5 operated. Whereas respondents who self-identified as model aircraft operators and not drone operators the average number of aircraft owned was noticeably larger at 12.2 with 7.3 operated in 2023.

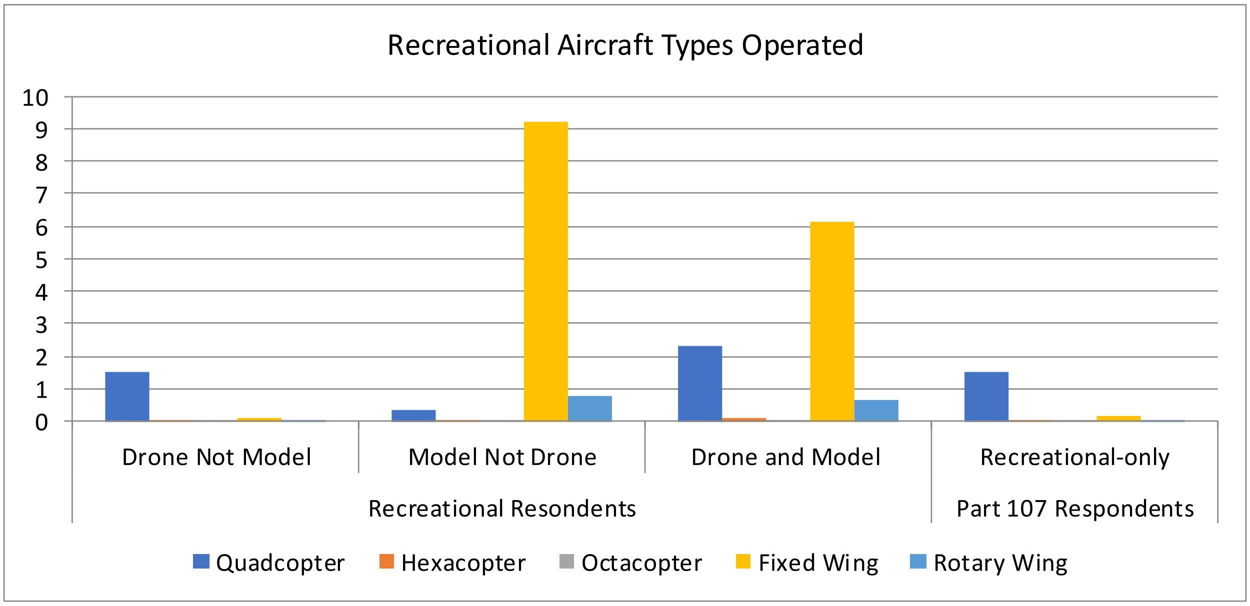


[55] These numbers represent a conservative cleaning of the data where less than 0.5% of respondents were removed. Recreational registrants who indicated greater than 3,000 recreational flights a year, an average flight duration of over 300min, or other extreme outliers were not included in the analysis.



Regarding the number of aircraft operated in 2023 respondents from the recreational registry reported an average of 1.22 quadcopters, 3.1 fixed wing aircraft, and less than 0.3 for all other airframe types (i.e., hexacopter, octocopter, rotorcraft, and "other"). Respondents who self-identified as a drone operator and not a model aircraft operator reported an average of 1.3 quadcopters operated in 2023, 0.1 for fixed wing aircraft, less than 0.1 for all other airframe types. Respondents who self-identified as a model aircraft operator and not a drone operator, reported an average of 0.3 quadcopters operated in 2023, 8.1 for fixed wing aircraft, 0.7 for rotary wing aircraft and less than 0.1 for all other airframe types. This difference in airframe types across recreational registrants who self-identify as drone versus model aircraft operators suggests that there exists some heterogeneity in the recreational registrants beyond the distinction based in the frequency of operations.





The flight behavior for Part 107 registrants is complicated by the diversity of the population. As discussed above, nearly one half of registered Part 107 operators self-identified as recreational only operators. These self-identified recreational-only Part 107 operators represent a distinct category of operator and have distinct flight characteristics. As such, the FAA sought to differentiate nonrecreational Part 107 operations from recreational operations. Therefore, Part 107 registrants were asked specifically about the number of recreational and nonrecreational flights they conducted in 2023. For Part 107 respondents who indicated zero nonrecreational and at least one recreational flight (36.1%), they were classified as recreational-only Part 107 operators and subsequent survey questions targeted their recreational activity. Whereas, for Part 107 respondents who indicated at least one nonrecreational flight (52.5%), they were classified as non recreational Part 107 operators and subsequent survey questions targeted nonrecreational activity.

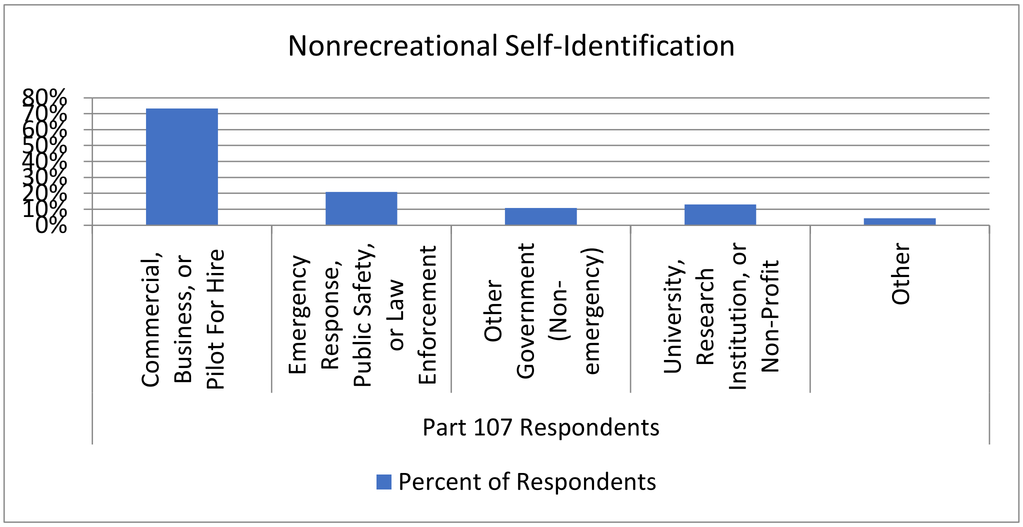
Recreational-only Part 107 - as defined by their annual reported flights - also self-identified as recreational operators (97.7%) with 95.9% of that group self-identifying as a recreational drone operator and 10.0% self-identifying as a model aircraft operator, indicating consistency across the self-identification question and the annual flight classification.

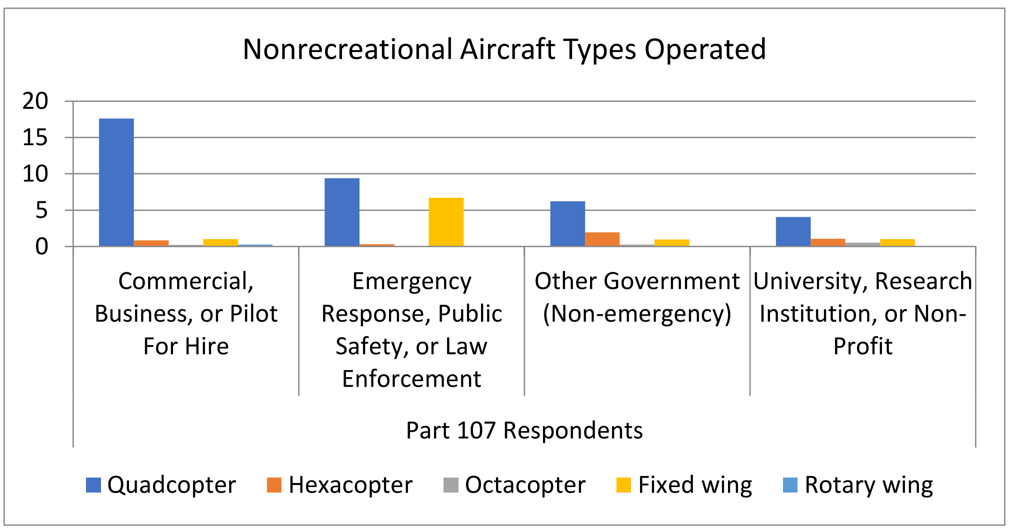
Recreational-only Part 107 operators reported an average of 18.1 annual recreational flights with a median of 6 flights. These operated also reported an average of 1.9 aircraft owned and 1.6 aircraft operated in 2023 with an average of 1.5 quadcopters, 0.19 fixed wing, and less than 0.02 other airframe types. Given the fleet and flight profile of this group, they seem to be more akin to novice drone operators in the recreational registry than the recreational enthusiast or model aircraft operators.

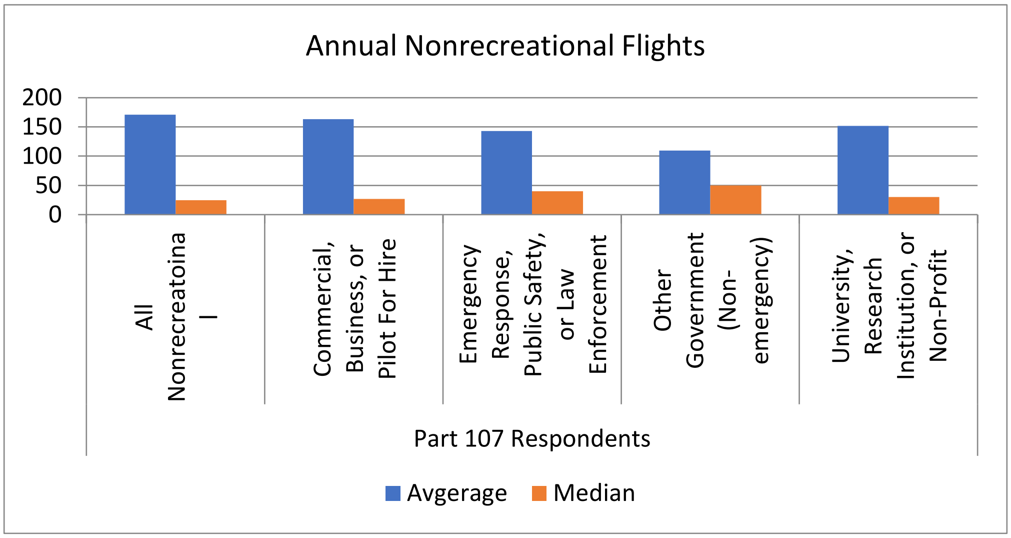
This suggests that there could be some confusion among operators regarding which registry is more appropriate to their operations. One counter argument is that this portion of recreational-only Part 107 operators are seeking expanded flying privileges with Part 107 waivers unavailable to recreational registrants. However, only 5.0% (16 respondents) of this group reported seeking a waiver in 2023 with 17.2% (55 respondents) indicating their intention to seek a waiver in 2024. Though within the current rules it is entirely acceptable for a Part 107 registrant to operate solely recreationally, these operators might be better served by the section-44809 recreational registry given the lower burden required to operate.

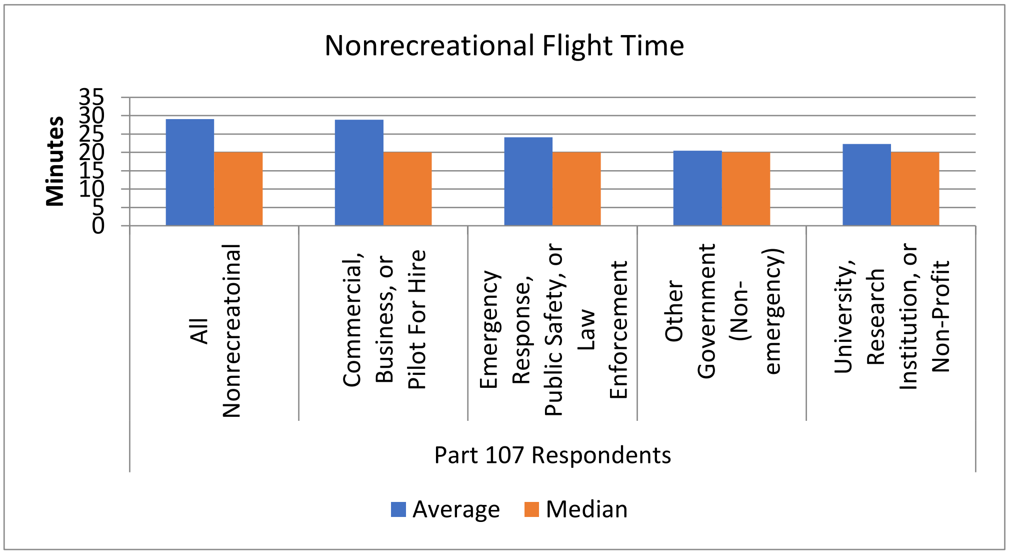
For nonrecreational Part 107 classified operators (at least one nonrecreational flight in 2023), 91.1% self-identified with a nonrecreational category, and 8.9% self-identified only as a recreational operator.[56] For nonrecreational Part 107 classified operators who self-identified with a nonrecreational activity, 73.2% self-identified as commercial, business, or pilot for hire reporting the following averages of 162.9 annual nonrecreational flights, 28.9 minutes a flight, 5.7 aircraft owned, and 4.8 aircraft operated in 2023. A further 20.8% self-identified as emergency response, public safety, or law enforcement reporting the following averages of 142.9 annual nonrecreational flights, 24.1 minutes a flight, 9.7 aircraft owned, and 8.3 aircraft operated in 2023. A further 13.0% self-identified as university, research institution, or non-profit reporting the following averages of 151.8 annual nonrecreational flights, 22.3 minutes a flight, 6.8 aircraft owned, and 3.8 aircraft operated in 2023. A further 10.8% self-identified as other government (non-emergency) reporting the following averages of 109.7 annual nonrecreational flights, 20.5 minutes a flight, 7.1 aircraft owned, and 4.1 aircraft operated in 2023. Additionally, a minority of 4.4% (57 respondents) self-identified as “other”.

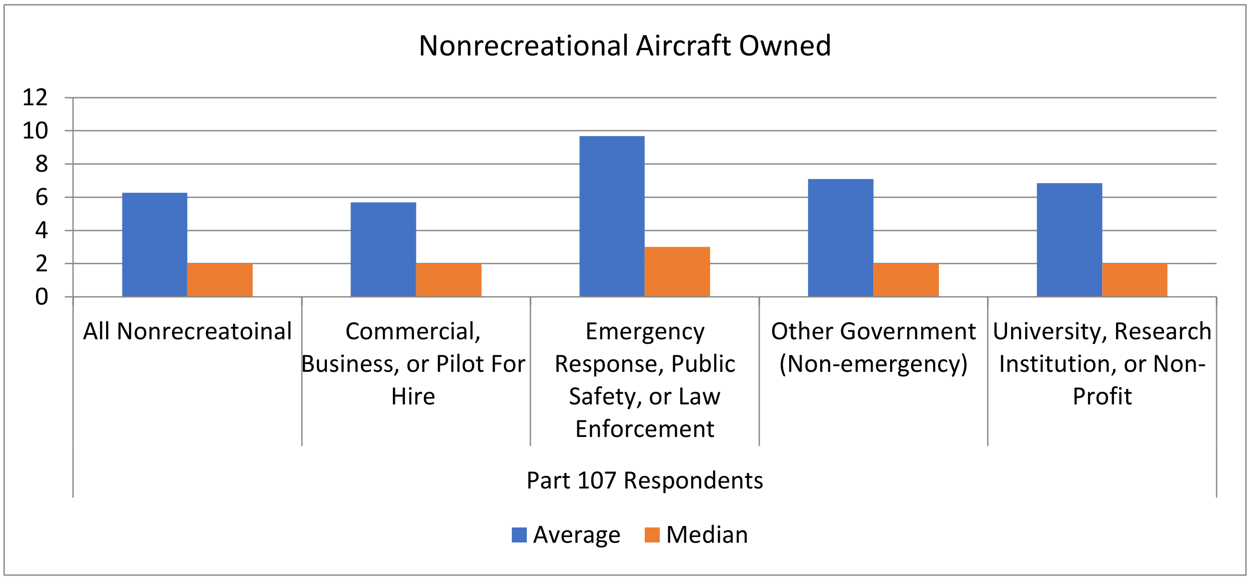
[56] These statistics reflect the active fleet of recreational UAS operators. As such, all operators who reported that they did not operate a sUAS aircraft in 2022 were removed from the data.


Nonrecreational Self-Identification
80%
70%
60%
50%
40%
30%
20%
10%
0%
Commercial, Business, or Pilot For Hire
Emergency Response, Public Safety, or Law Enforcement
Other Government (Non-emergency)
University, Research Institution, or Non-Profit
Other
Part 107 Respondents
Percent of Respondents


Nonrecreational Aircraft Types Operated
20
15
10
5
0
Commercial, Business, or Pilot For Hire
Emergency Response, Public Safety, or Law Enforcement
Other Government (Non-emergency)
University, Research Institution, or Non-Profit
Part 107 Respondents
Quadcopter
Hexacopter
Octacopter
Fixed wing
Rotary wing


Annual Nonrecreational Flights
200
150
100
50
0
All Nonrecreatoinal
Commercial, Business, or Pilot For Hire
Emergency Response, Public Safety, or Law Enforcement
Other Government (Non-emergency)
University, Research Institution, or Non-Profit
Part 107 Respondents
Avgerage
Median


Nonrecreational Flight Time
Minutes
35
30
25
20
15
10
5
0
All Nonrecreatoinal
Commercial, Business, or Pilot For Hire
Emergency Response, Public Safety, or Law Enforcement
Other Government (Non-emergency)
University, Research Institution, or Non-Profit
Part 107 Respondents
Average
Median



Nonrecreational Part 107 classified operators also reported their annual number of recreational flights. Overall, these respondents reported an average of 28.3 annual recreational flights with a median of 5, fewer than the number or nonrecreational flights. Just over three quarters (76.2%) of respondents reported more annual nonrecreational flights than recreational. Those who self-identified as university, research institution, or non-profit reported the most annual recreational flights with 36.7 and those self-identifying as commercial, business, or pilot for hire with the fewest at 26.4 annual recreational flights. Just over one third (34.0%) of respondents reported zero recreational flights in 2023. Those reporting zero flights by self-identification group varied slightly, with 44.6% of other government (non-emergency) operators reporting zero recreational flights to 31.9% of commercial, business, or pilot for hire operators.

These data demonstrate that the self-identified commercial operators are the largest group, have the longest average flight time, and the highest number of nonrecreational flights. When looking at the median number of flights this group has the smallest value at 27 annual nonrecreational flights with the other group medians between 30 and 50. This suggests that there exists a smaller group of more frequent flyers while most fly less frequently.

With respect to the 8.9% of nonrecreational Part 107 classified operators who self-identified only as recreational operators, they flew an average of 14.4 annual nonrecreational flights and 32.2 annual recreational flights. Compared to the 91.1% of operators who self-identified with a nonrecreational category the 8.9% reported less than one tenth of the annual nonrecreational flights and 27% more annual recreational flights. As such, these operators conduct so few nonrecreational flights and on average more recreational flights that they might only consider themselves recreational operators.

The FAA added additional questions to the 2023 survey to estimate the lifespan of UAS. Respondents provided the number of UAS they had decommissioned[57] in 2023 and how long they had owned that UAS. Recreational respondents reported an average of 4.1 years (median of 3) of ownership prior to decommissioning, and for recreational respondents who decommissioned at least one UAS the average number UAS decommissioned was 2.3. For self-identified model aircraft operators who did not identify as drone operators the average ownership prior to decommissioning was slightly longer at 4.3 years (median of 3) and they reported slightly more aircraft decommissioned at 2.6 for those who decommissioned at least one UAS. For self-identified drone and not model aircraft operators the reverse was true with an average ownership of 3.8 years (median of 3) and 1.5 decommissioned UAS in 2023.

Nonrecreational Part 107 respondents reported an average of 3.6 years (median of 3) of ownership prior to decommissioning and for those who decommissioned at least one UAS they reported an average of 4.5 UAS decommissioned in 2023. Recreational-only Part 107 respondents reported an average of 3.3 years (median of 3) of ownership prior to decommissioning and for those who decommissioned at least one UAS they reported an average of 1.6 UAS decommissioned in 2023. Therefore, all groups had a median of 3 years of ownership prior to decommissioning their UAS. This estimate is congruent with current FAA estimates of UAS lifespan.

In general, these data illuminate meaningful differences with respect to fleet and flight characteristics between distinguishable groups of registrants within both the Recreational Registry and the Part 107 Registry. Within the Recreational Registry there are two distinct groups, those who self-identify as drone operators and those who self-identify as model aircraft operators; with model aircraft operators having larger fleets comprised of more fixed wing aircraft, operating more frequently, and operating for slightly shorter periods of time as compared to drone operators. Within the Part 107 Registry two distinct primary groups appear. First, those engaged solely in recreational activities, whose activity resembles recreational drone operators more than the other Part-107 operators. Second, a nonrecreational group engaged in a diversity of nonrecreational and recreational activities. Within this nonrecreational group further differentiation is possible by self-identification.

Remote Pilot Forecast

An important final metric in commercial small drones is the trend in remote pilot (RP) certifications. RPs[58] are used primarily to facilitate commercial and public use small drone flights, as discussed in the preceding section. As of December 2023, a total of 368,883 RP certifications had been issued, an increase of almost 64,000 from the same time last year (2022) and almost 120,000 higher than the year before in 2021.

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 Rat-

[57] Decommissioned was defined as disassembled, parted out, defective or damaged beyond use, scrapped, or having become obsolete.

[58] 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).

ing 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. The 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.

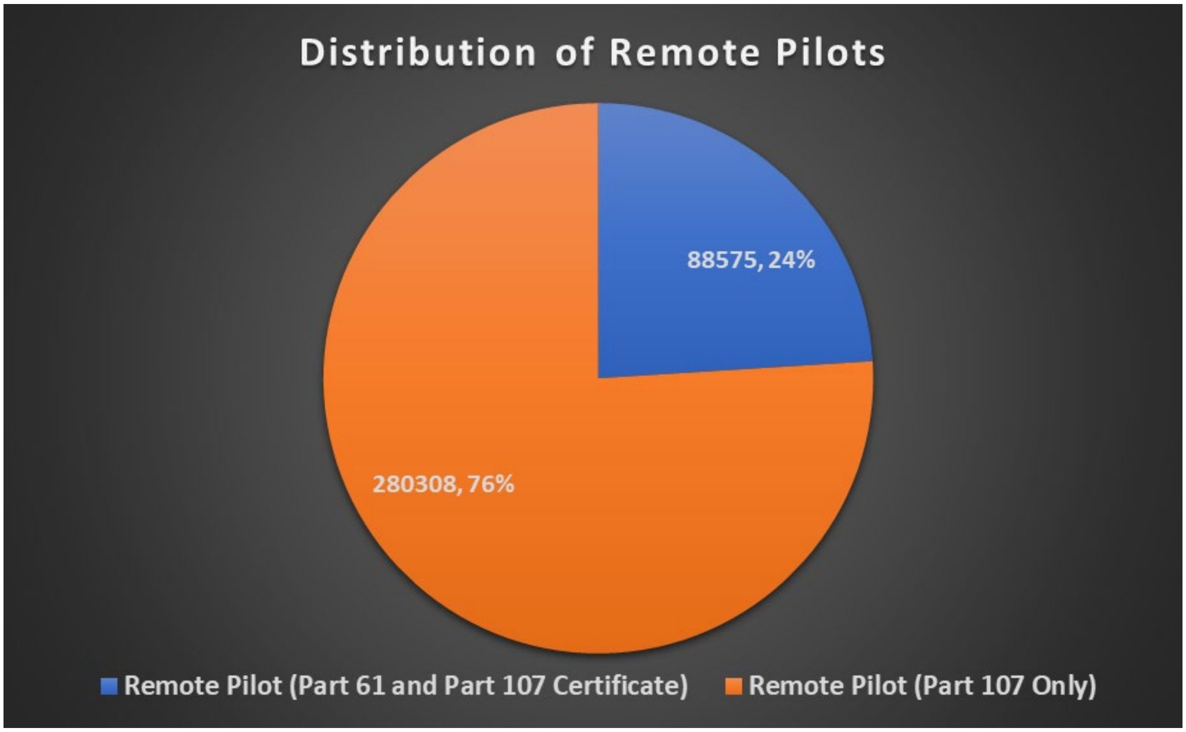
Certifications for part 61 operators, on the other hand, require an applicant to hold a pilot certificate issued under 14 CFR part 61, and to have completed a flight review within the previous 24 months. Because part 61 operators, unlike the part 107 operators, already have IACRA profiles, they start by completing FAA Form 8710-13 in IACRA 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.[59]

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.

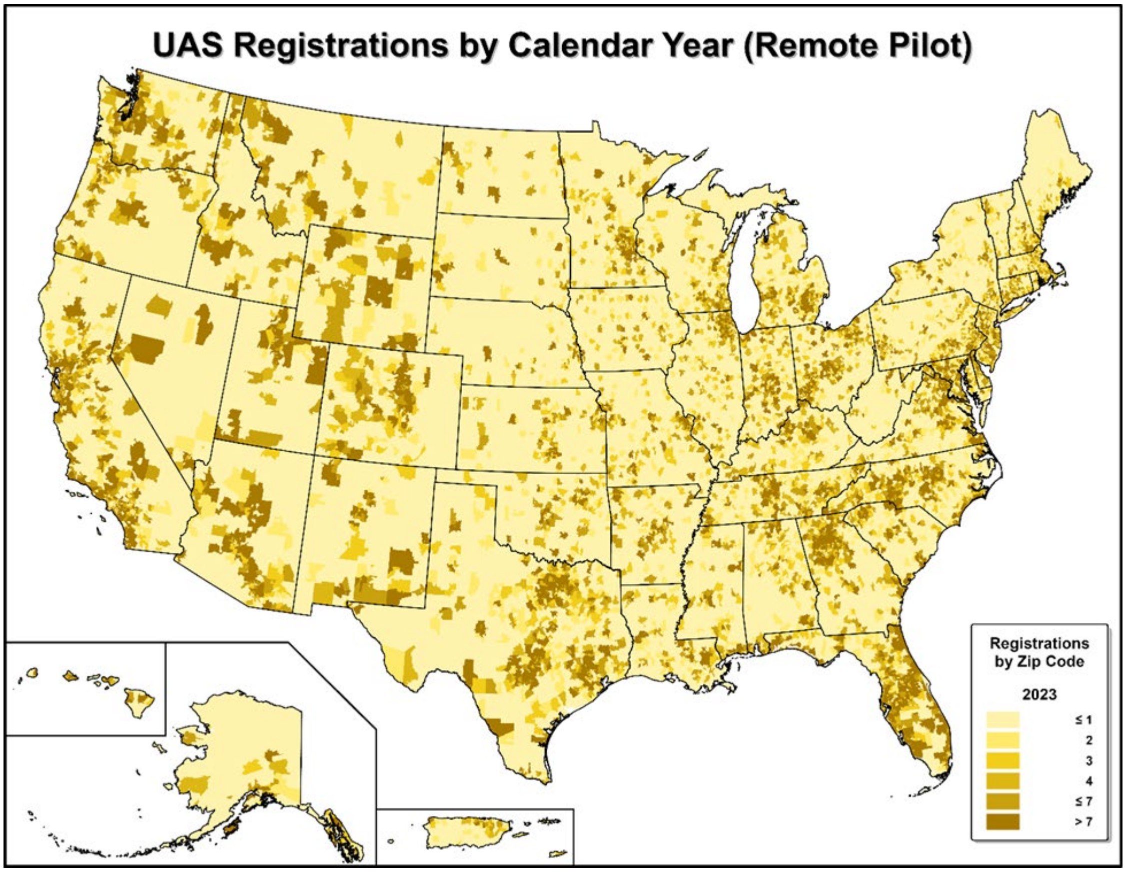
The chart below provides numbers as of December, 2023 together with distribution of these two types of RPs who presently have certificates.

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



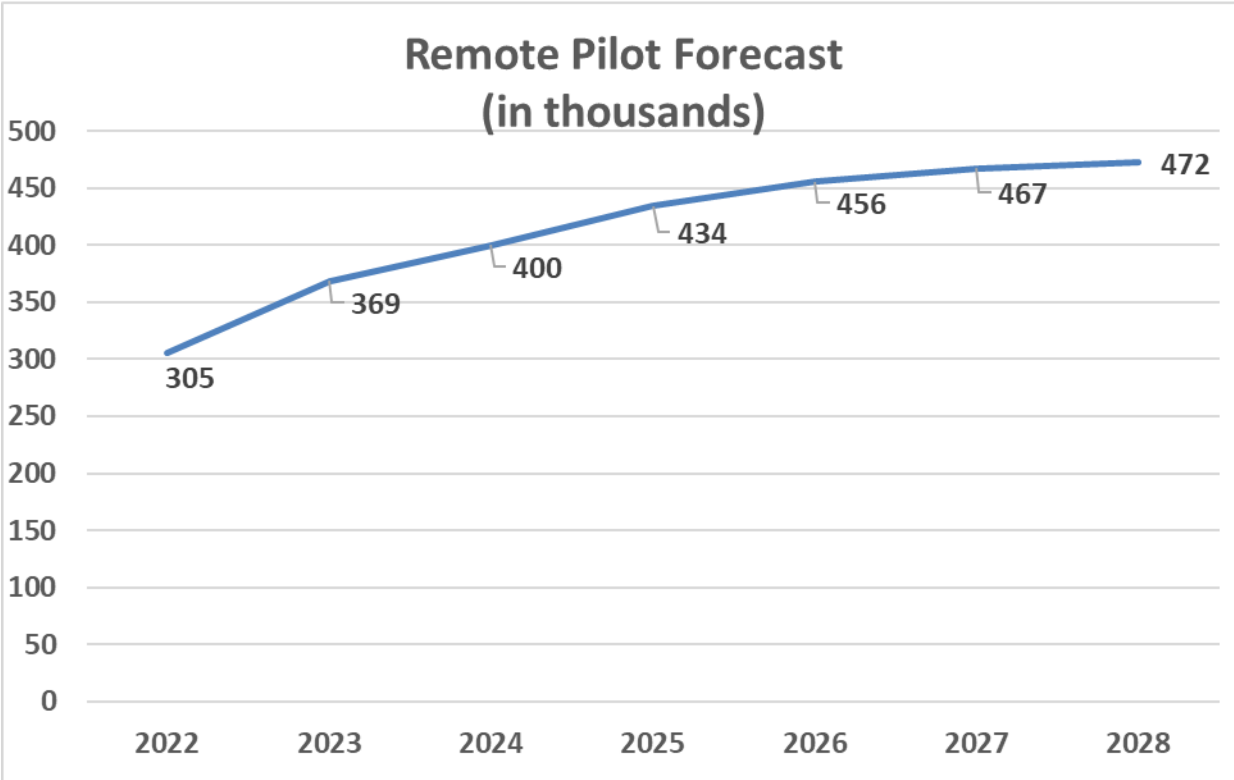
Around 76% of the RPs are Part 107 RPs only. Over 90% of those who took the exam passed and obtained RP certification.[60] A cumulative density distribution of remote pilots by zip codes in 2023 is provided in the map below.

[60] Comparing data from last year, we notice that RP numbers have been revised downwards, by around 4,000 (or around -2%), over the entire program period. This is due to data clean up throwing out duplicate data and wrong data entry noticed during renewal.



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 338,907 by the end of 2023. Actual registrations by the end of 2023 totaled 368,883 (or almost 30,000 less than from last year's projection) thus actual exceeding last year's projection by 8.85% for 2023. Alternatively, last year's projection undershot actual by -8.13% or by -29,976.



Given the actual numbers at the end of 2023, RPs are set to experience tremendous growth following the growth trends of the commercial (or Part 107) small drone sector. Starting from the base of 368,883 RPs in 2023, commercial activities may require over 472,269 RPs in five years, a 1.3-fold increase that may provide tremendous opportunities for growth in employment—over 103,386 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.

Large UAS

Part 107 limits the gross takeoff weight of unmanned aircraft (or sUAS) to below 55lbs. Thus, unmanned aircraft with gross takeoff weights above 55lbs must operate under separate rules and are thus considered a separate category of UAS, which we refer to as simply large UAS (lUAS) for this analysis. Since these lUAS are not type certified and do not fall under the Part 107 operating rules, operation of these aircraft requires a section 49 U.S.C § 44807 exemption or a public aircraft operator (PAO) certification.[61] In addition, the FAA requires lUAS operating under a 44807 exemption or PAO to receive a tail number by registering the unmanned aircraft in the part-47 aircraft registry.[62] As such, the lUAS fleet and operations are not contained in or correlated with the sUAS discussed in previous sections.

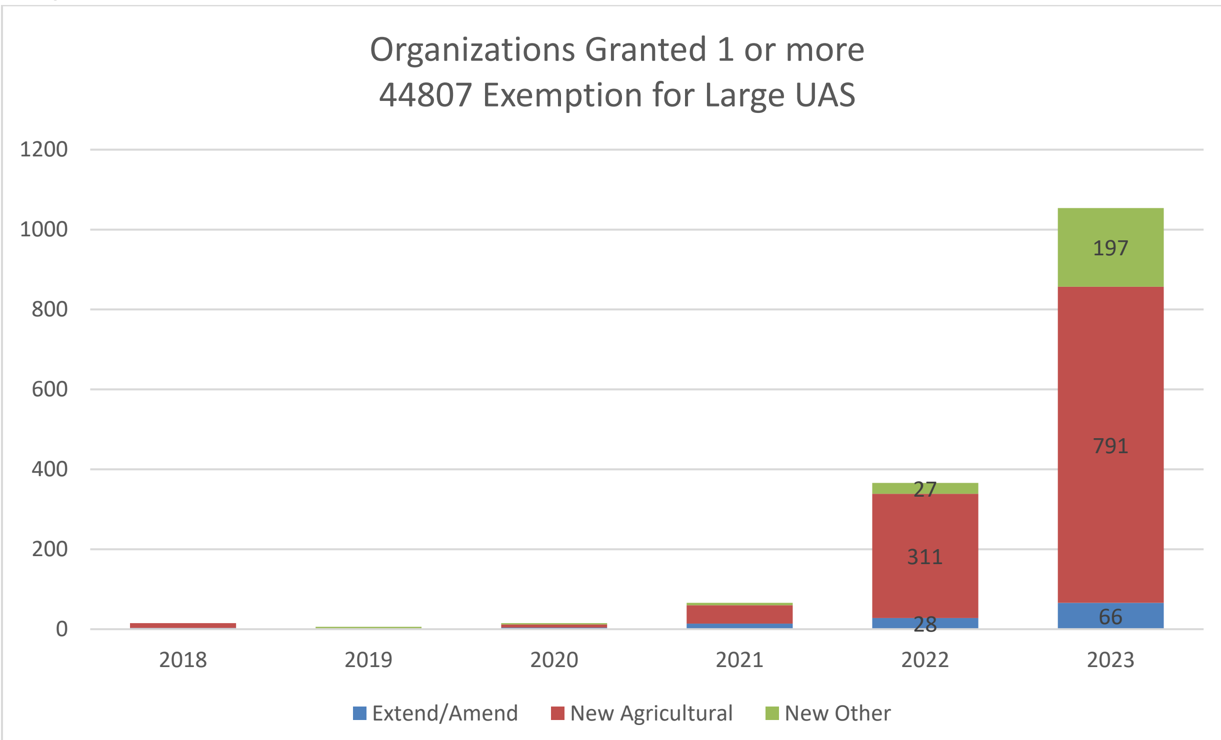
The FAA has been granting 44807 exemptions since their introduction in the FAA Reauthorization Act of 2018. Both applications for a 44807 exemption by

[61] See bit.ly/3KxiuVX for more details.

[62] See bit.ly/3ZIcCxJ.

individuals and organizations and the decisions by the FAA are publicly available.[63] Since 44807 exemptions are required to operate a IUAS for commercial purposes, these exemptions are a leading indicator of both the purchases, which increase the fleet, and the operations of non-military IUAS. The 44807 exemption was slated to sunset in 2023, but the continuing resolution signed in Sept. 2023 extended the 44807 exemption's sunset to Dec. 31, 2023.[64] Given exemptions are only valid for two years from the date they are granted, we could see all operations of IUAS disappear by 2025 without additional legislation.

The FAA has granted 1,448 exemptions in 2023, a remarkable 245% increase from 2022. Just under 5% of exemptions (67) were amendments or extensions of existing exemptions. Roughly 77% of exemptions (1,131) were granted for new agricultural-spraying applications. The remaining roughly 19% (272) were for other applications, including aerial photography and parcel delivery.



The rapid increase in exemptions granted suggests that the safety cases for specific operations have been sufficiently demonstrated to regulators such that granting exemptions for these narrow operations is now routine. 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

[63] All 44807-exemption applications and decisions are available at regulations.gov in the "Other" category.

[64] See http://tinyurl.com/mpkhmzzd

observed operating in the NAS, particularly in the controlled airspace environment.

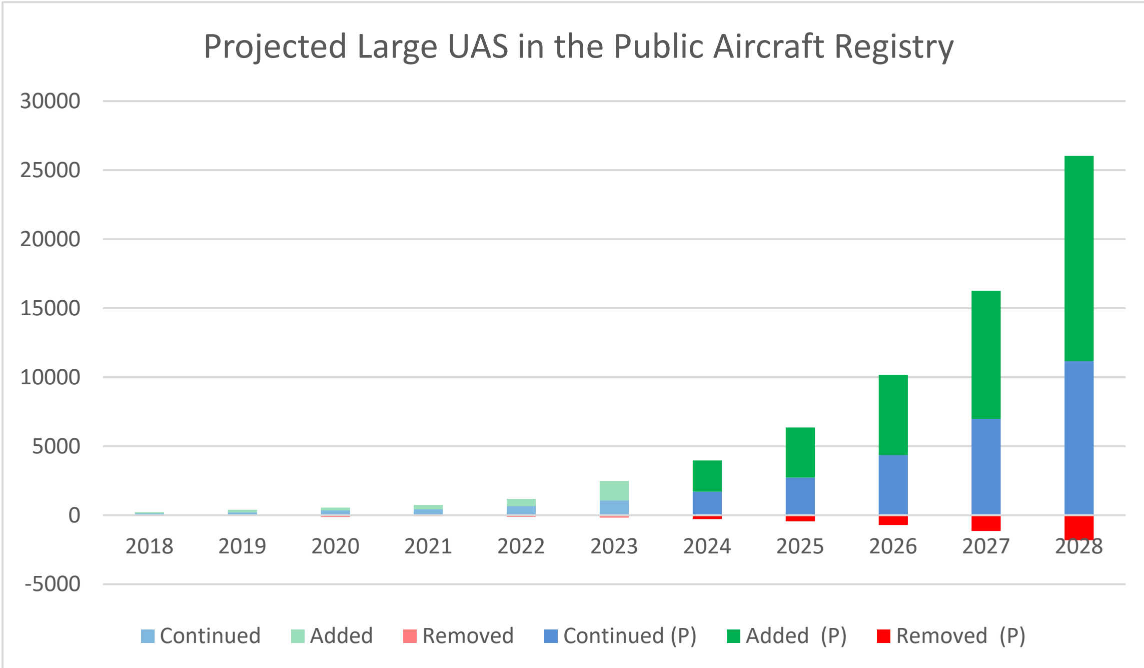
Since IUAS are required to register with the Part-47 Aircraft Registry (PAR), we can use the PAR to estimate the IUAS active fleet. Using the Aircraft Reference file from the publicly available PAR, we identify the IUAS in the Aircraft Registration Master file and the Deregistered Aircraft file from which we calculate the active fleet of IUAS.[65] In 2023, 1,066 new IUAS aircraft were added to the PAR, a 174 percent increase from 2022. Sixteen percent of aircraft registered at the end of 2023 (173) were delisted in 2023, producing an active fleet of 2,311 IUAS by the end of 2023.

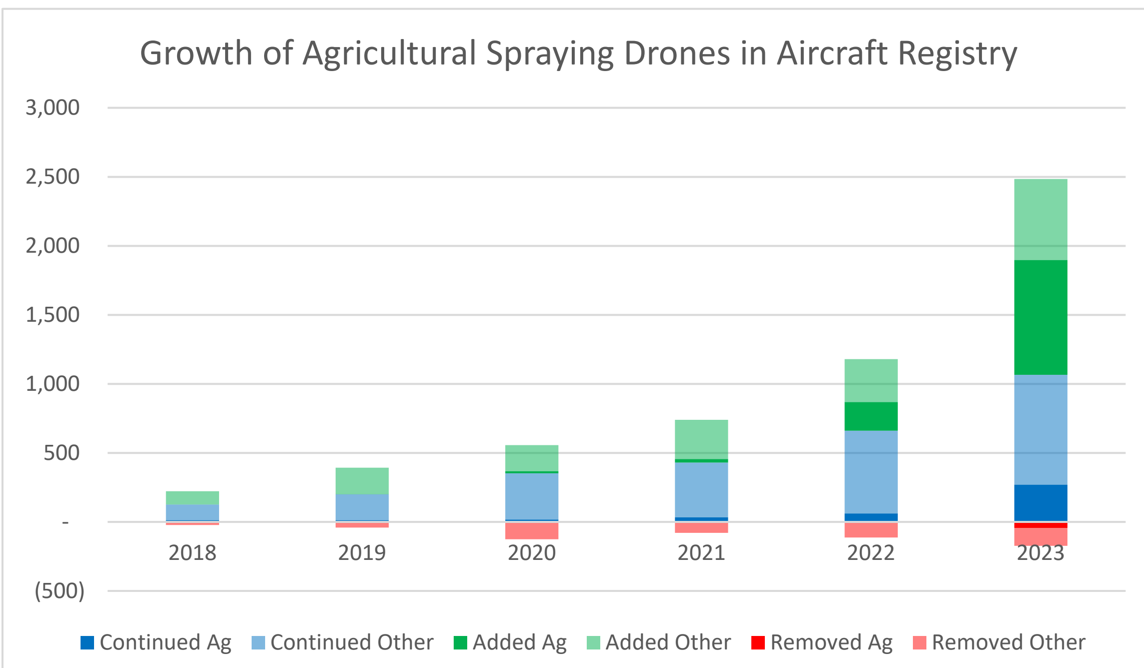
With robust demand for IUAS operations indicated by 44807 exemptions, we expect the growth of new IUAS over the next 5 years to keep pace with the growth observed in 2023. As such, we expect 14,859 new IUAS will be added to the PAR in 2028, with a total active IUAS fleet of over 24,000 aircraft by the end of 2028. This forecast assumes that 44807 exemptions, or an equivalently permissive rule, remains in place until 2028. However, the uncertainty regarding the availability of the 44807 exemptions presents a headwind for the expansion of the IUAS sector.

Although the active fleet can be observed from the PAR, the operations of IUAS are more difficult to observe. However, the majority of registered IUAS are agricultural - spraying aircraft from just three manufacturers.[66] Moreover, the portion of new IUAS registered in the PAR has increased from 40 percent in 2022 to 59 percent in 2023. We expect this proportion to increase to around 80 percent of new IUAS registered in the PAR until a new class of 44807 exemptions, or the equivalent, are issued in similar numbers to the agricultural spraying exemptions. As such, the vast majority of IUAS operations will be conducted close to the ground with only a few organizations operating IUAS in the NAS, let alone in the controlled airspace.

[65] The Public Aircraft Registry data for 2022 is available at https://bit.ly/433iqET. Unmanned 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 unmanned 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, older registrations, and delisted registrations are used to construct the active IUAS fleet.

[66] DJI, Hylio, and Yamaha's agricultural-spraying UAS account for just over 50% of the registered large UAS in the part-47 aircraft registry.


Projected Large UAS in the Public Aircraft Registry
30000
25000
20000
15000
10000
5000
0
-5000
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
Continued
Added
Removed
Continued (P)
Added (P)
Removed (P)


Growth of Agricultural Spraying Drones in Aircraft Registry
3,000
2,500
2,000
1,500
1,000
500
-
(500)
2018
2019
2020
2021
2022
2023
Continued Ag
Continued Other
Added Ag
Added Other
Removed Ag
Removed Other

UAS Imports

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.[67] As part of the update, UAS received their own categories, separating UAS from crewed aircraft or toys. The new schedule splits UAS into several categories based on weight and a special category for UAS capable of passenger services (See table below).[68] The new HTSUS has given the FAA additional information regarding the number of UAS purchased in the United States. This is particularly useful given that the vast majority of sUAS operators' equipment within the United States are imported.

To map the HTSUS categories onto the categories commonly used in the Aerospace Forecast, we used the category of small UAS as defined by part 107 as the divider. For the purpose of this analysis, all UAS weights covered by part 107 (0.55lbs < UAS < 55lbs or roughly 250g < UAS < 25kg) are considered small UAS (sUAS). Any UAS that weighs less than a sUAS (UAS<0.55lbs), we consider a micro UAS (mUAS), and any UAS that weighs more than a sUAS (UAS>55lbs), we consider a large UAS (lUAS). As such, mUAS consists of HTSUS code 8806.21, sUAS consists of 8806.22 and 8806.23, and lUAS consists of 8806.24 and 8806.29.

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

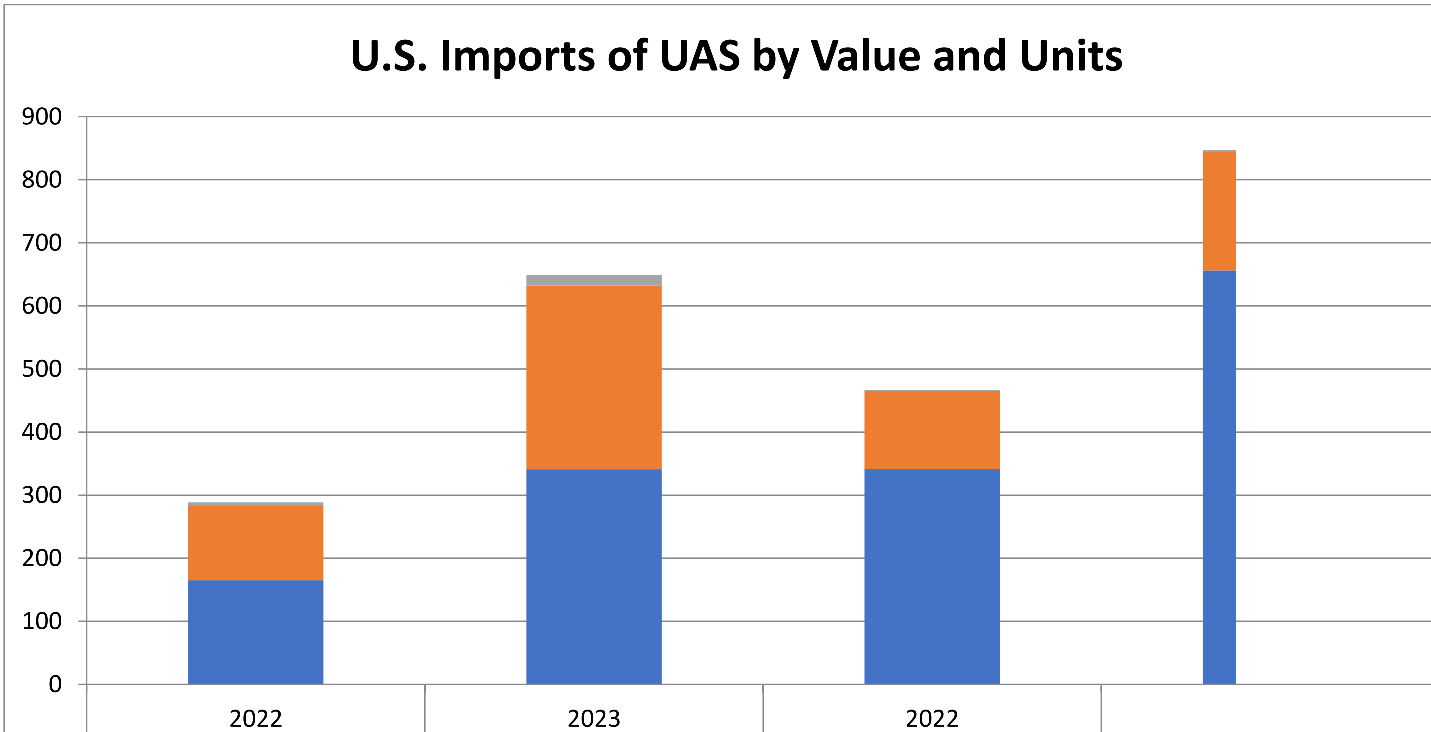
In 2023, the United States imported over 776,000 UAS worth US$586 million.[69] The value of UAS imports doubled from 2022 to 2023. The doubling was caused by two factors; first, the number of UAS aircraft imported increased by 66 percent from 2022 to 2023. However, the increase in units imported could be a function of the introduction of the new harmonized tariff codes (HTC) in 2022. Since the new HTC came into force at the end of January of 2022, the import data

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

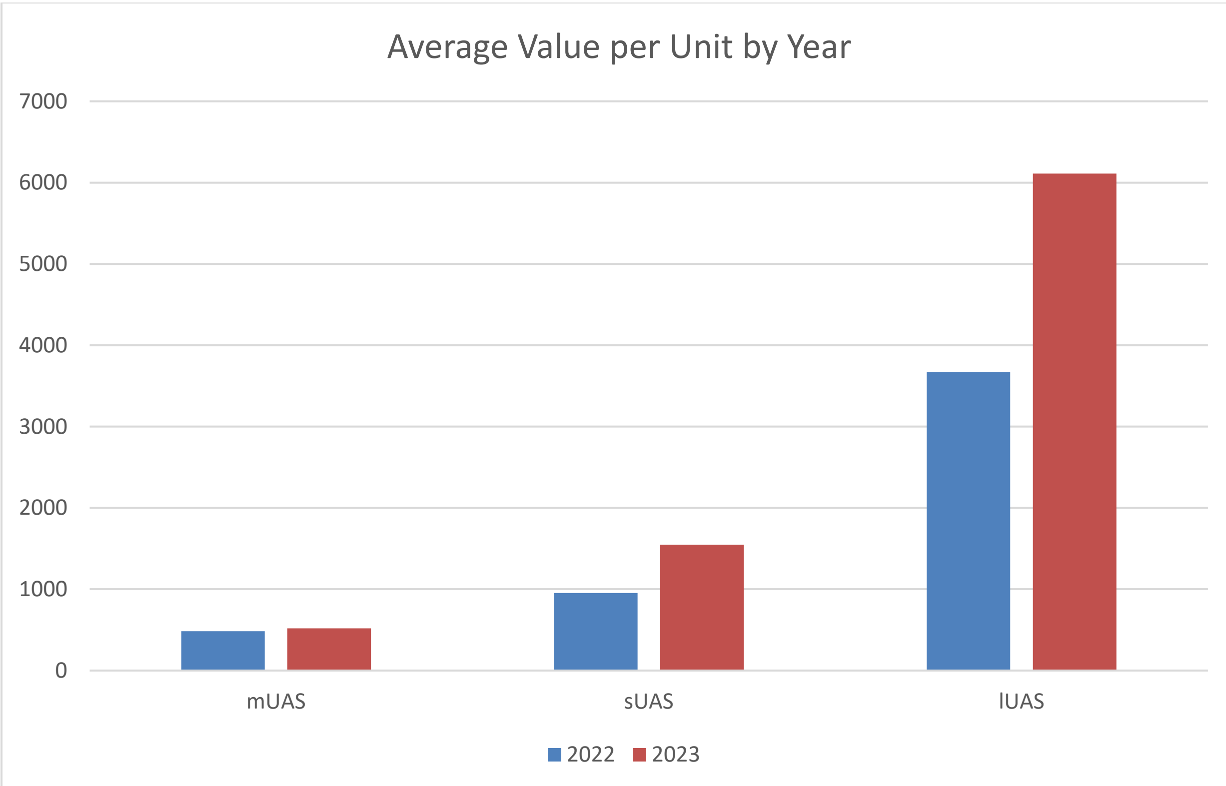
[68] The categories also included "Not Elsewhere Specified or Included (NESOI)" and "duplicate category" for each of the sub-category codes.

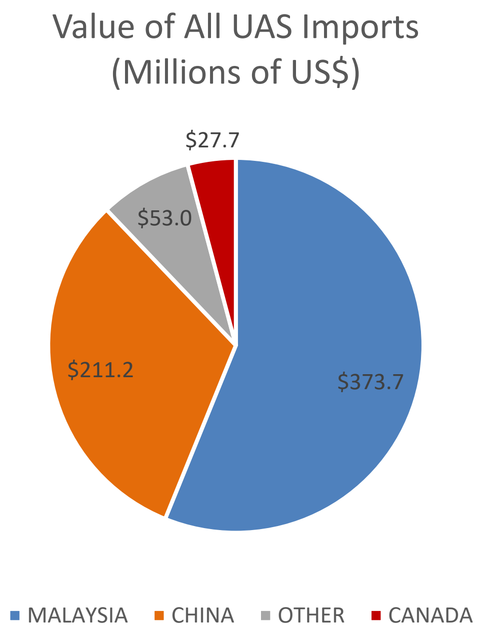
[69] All import numbers are for the values and units of UAS for consumption and exclude units in bonded warehouses. Values exclude duties, insurance, and freight.

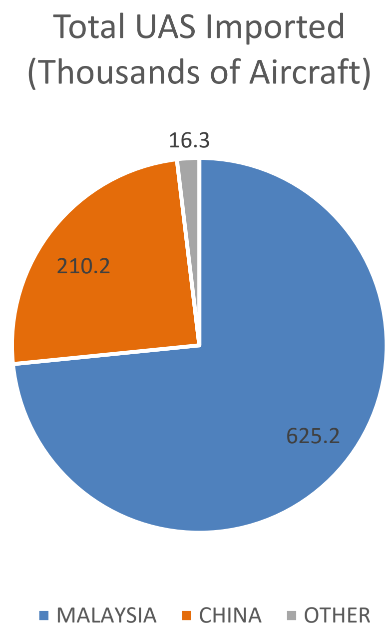
for UAS in 2022 only had 11 months compared to the full 12 months in 2023. Second, some importers, anticipating a change in HTC, could have moved up the dates of deliveries to ensure a more favorable treatment of their imports, reducing the reported UAS imported into the United States for 2022. As such, the actual growth of UAS imports is likely less than 66 percent between 2022 and 2023.



Corresponding to the increase in units imported, the average price per unit has increased for the three main categories of UAS. Micro UAS had only a marginal increase in price of only 6 percent, while sUAS and lUAS increased by 57 and 63 percent, respectively. These price increases reflect the general increase in the cost of goods and services within the United States as well as increased demand and technological improvements in the aircraft.


Average Value per Unit by Year
7000
6000
5000
4000
3000
2000
1000
0
mUAS
sUAS
lUAS
2022
2023





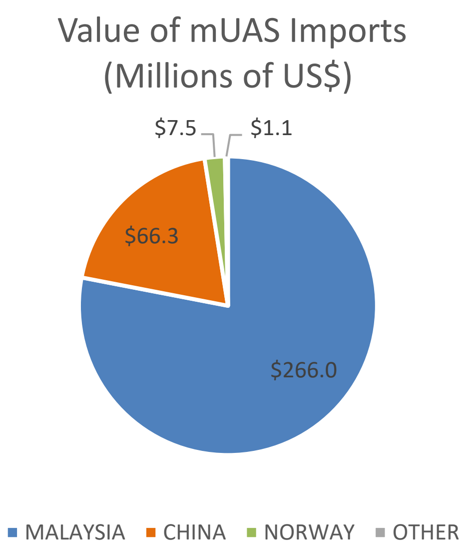
	Value (Million USD)	Aircraft (Thousands)	Average Price
CANADA	$ 27.7	2.2	$ 12,420
OTHER	$ 53.0	14.1	$ 3,760
CHINA	$ 211.2	210.2	$ 1,005
MALAYSIA	$ 373.7	625.2	$ 598

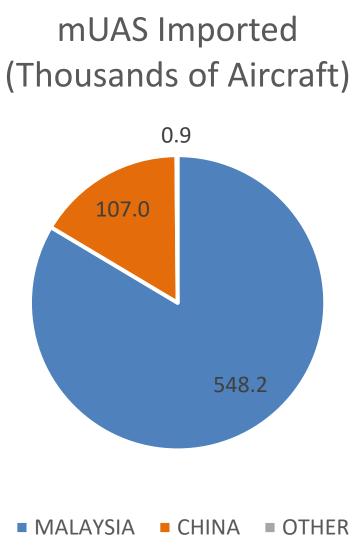
The vast majority of UAS imports, both in terms of value and units, are from either China or Malaysia with Canada being a notable exporter of UAS in terms of values. On average, both China and Malaysia are exporting low value UAS compared to other countries, with Malaysia have the lowest average price of a UAS.

A total of 600,000 mUAS were imported into the United States in 2023 with a value of over $262 million, a 58 percent increase from 2022.[70] China and Malaysia dominated this segment of the UAS market, exporting 101,600 and 497,400 units worth $63.3 million and $237.5 million, respectively. Between the two countries, their exports of mUAS to the United States made up 99.9% of the mUAS imported. However, Malaysia has seen more than a doubling of mUAS 2023 while exports from China fell marginally in 2023. This suggests that Malaysia is dominating the overall production of mUAS destined for the U.S. market. Norway is a notable exception to the two large exporters of mUAS. Norway's exports of mUAS to the

[70] All graphs of mUAS import values and units bundle all countries with less than 2% of the market into the OTHER category.

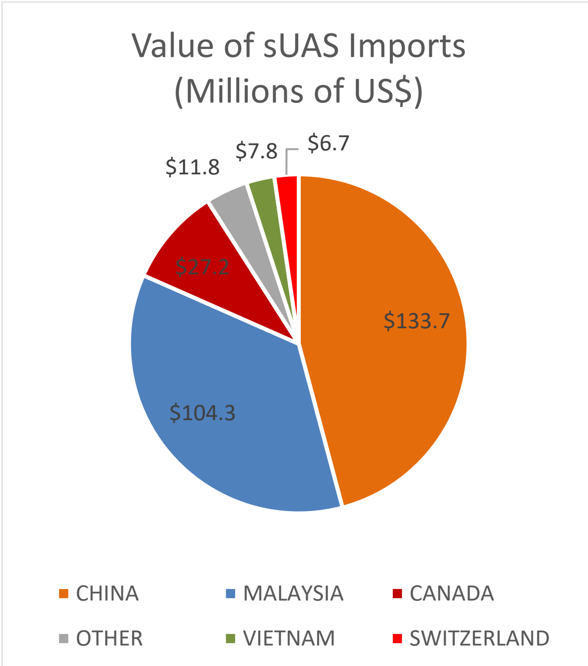
United States made up 2.5 percent of imports in terms of value and had one of the highest average value per unit of any category of UAS at over US$22,000 per aircraft. The United States imported a total of 174,200 units of sUAS in 2023 valued at $309.1 million, an almost tripling of value compared to 2022.[71] Imports from China and Malaysia dominate this segment of the UAS market as well with 94 percent of all imported sUAS originating in these two countries. However, China has only grown their exports of sUAS by 60 percent between 2022 and 2023 while Malaysia's exports have increased an astounding six and a half thousand percent. In terms of value, three other countries play a significant role: Canada, Switzerland, and Vietnam. All three have 2% or more share of the U.S. imports of sUAS by value. Both Canada and Switzerland exported relatively few sUAS to the United States, but the average value per unit was ten times that of sUAS exported from China or Malaysia. Conversely, Vietnam's exports had only slightly more value per unit than China and Malaysia, suggesting that Vietnam's UAS manufacturers may be competing for similar price points of sUAS as China and Malaysia.

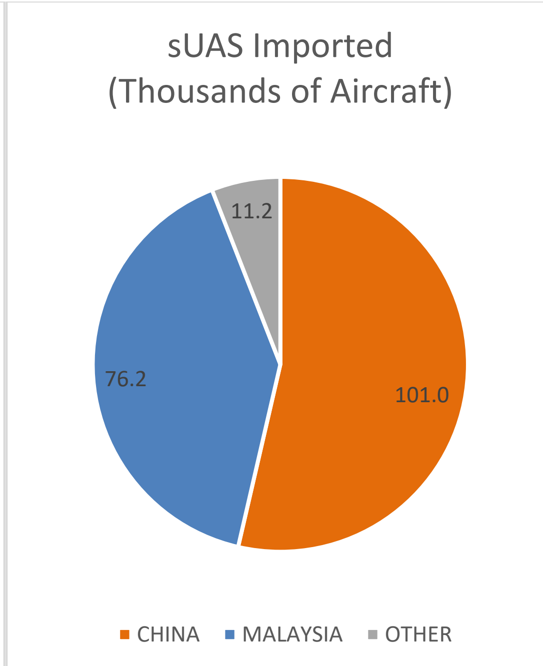




	Value (Millions of USD)	Aircraft (Thousands)	Average Price
NORWAY	$ 7.5	0.3	$ 22,640
OTHER	$ 1.1	0.5	$ 2,110
CHINA	$ 66.3	107.0	$ 620
MALAYSIA	$ 266.0	548.2	$ 485

[71] All graphs of sUAS import values and units bundle all countries with less than 2% of the market into the OTHER category.





	Value (Million USD)	**Aircraft**	**Average Price**
SWITZERLAND	$ 6.7	0.4	$ 16,213
CANADA	$ 27.2	1.8	$ 14,951
VIETNAM	$ 7.8	3.6	$ 2,188

lUAS was the most diverse of the imports. In 2023, the United States imported 2,600 lUAS valued at $15.5 million, almost tripling between 2022 and 2023.[72] Once again, China was the dominant exporter to the United States, both in terms of units and value, and increased the exports of lUAS by 150% to the United States between 2022 and 2023. European countries are notable producers of lUAS with the U.K. and Spain exporting 98 and 492 aircraft to the United States valued at US$3.4 million and US$680,000, respectively. In terms of value, Australia, France, and Latvia are also significant exports of lUAS, specializing in high value per unit lUAS.

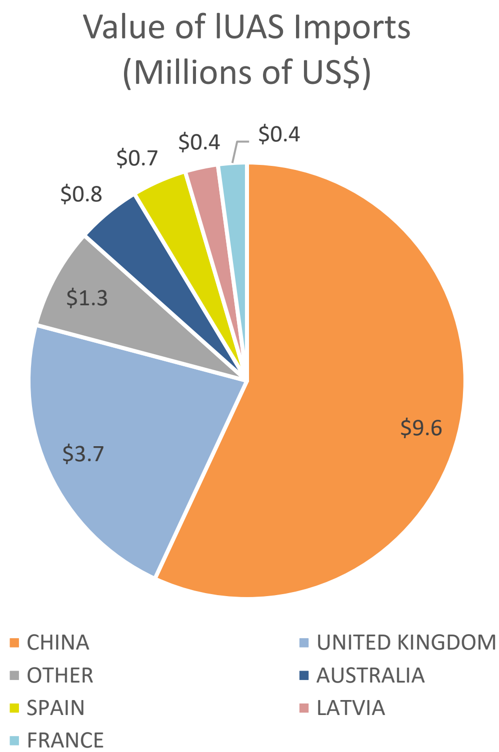
Although China plays a major role in all three segments of the UAS markets, it must contend with growing Malaysian and European UAS exports. Malaysia, who currently dominates the mUAS market, could see exports of sUAS overtake China's exports as the dominant exporter of sUAS to the American market. However, China has significantly increased their exports of lUAS to the United

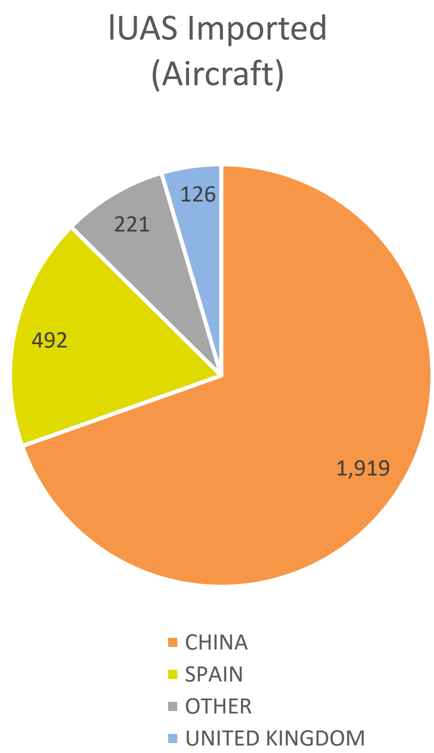
[72] Like in case of mUAS and sUAS, all graphs of lUAS import values and units bundle all countries with less than 2% of the market share into the OTHER category.

States. This is most likely from the increased acceptance of agricultural spraying in the United States with lUAS, which spurred increased purchases of the DJI Argas series (see the Large UAS section).

In general, the UAS import data seems to show a dichotomy between Europe / Commonwealth Countries and Asian Countries, with the former producing fewer high valued UAS and the later producing many lower cost aircraft. Spain's exports of lUAS are a notable exception, producing almost 20 percent of all lUAS with the lowest value per unit.

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, the 174,000 sUAS imported into the United States should translate to higher registration numbers in both recreational and part 107 registries. Given that 115,000 UAS have been registered under part 107 and around 71,000 new registrants in the recreational registry, the vast majority of which are sUAS, 174,000 sUAS imports seems in line with registration data with remaining aircraft produced domestically. As such, the growth of UAS imports should reflect the growth of the UAS fleet in the United States. However, readers should be cautioned that the growth rates observed this year are not correct. Observed growth in UAS imports between 2022 and 2023 are partially due to an artifact of when HTC were changed and the start of when data on UAS imports was collected. As such, we do not expect the growth rates in imports to reflect fleet growth until after the end of 2024.





	Value (Millions of USD)	Aircraft	Average Price
AUSTRALIA	$ 0.8	10	$ 80,311
LATVIA	$ 0.4	13	$ 31,603
FRANCE	$ 0.4	16	$ 22,427
UNITED KINGDOM	$ 3.7	126	$ 29,687
OTHER	$ 1.3	182	$ 6,937
CHINA	$ 9.6	1,919	$ 5,000
SPAIN	$ 0.7	492	$ 1,388

Advanced 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."[73] [74] 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:[75]

- 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.[76] 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 $3.99.[77] This progress continued in 2023 and it may have exceeded one million deliveries globally thanks to new applications in delivering food, medication, and other goods.[78] The growth trajectory is anticipated to accelerate once FAA permits BVLOS operations more widely.[79] By 2030, package delivery is

[73] 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.
[74] See https://go.nasa.gov/40Y4hXM.
[75] See https://bit.ly/3U7W2pA.
[76] 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.
[77] See https://bit.ly/3Kv8QTZ for a discussion.
[78] See http://tinyurl.com/yeynkwb6.
[79] Last year, the FAA approved Wing's detect and avoid (DAA) approach for beyond visual line of sight (BVLOS) operations without visual observers through a summary grant, which will allow drones to use Automatic Dependent Surveillance-Broadcast-based (ADS-B) DAA inside a major area of Dallas, TX airspace where traditional aircraft are required to continually broadcast their position. While Wing has already been serving customers at a 6 mile radius from nests in Frisco, TX, this summary grant enables FAA to

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 in the US.[80] At present, commercial drone deliveries in North America have been estimated to be around 158,000 by the end of 2023.[81]

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 2022.[82] Collectively, the industry recorded over 6,000 cumulative flight hours of aircraft testing over the past few years, many in 2022 and 2023.[83] Interestingly, many of these flight testing is now moving from remote to pilot on board facilitating "for credit" flight testing by the FAA.[84]

The increasing number of flight tests and data collection are paving the way for type certification (TC) of eVTOL aircraft.[85] 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.[86] 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,

move toward BVLOS operations without visual observers across Dallas and similar airspace surrounding other major US cities, adding to the momentum of the drone delivery industry at large. Exemption No. 18339D [see http://tinyurl.com/mtwxc647] is the full grant FAA provided to UPS Flight Forward in September, 2023 in conjunction with full grants for Phoenix Air Unmanned, LLC and uAvionix Corporation. Since then, FAA issued summary grants for Causey Aviation Unmanned, Inc, Zipline and Amazon Prime Air as well.

[80] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. [See http://tinyurl.com/m9jb7yrx; and http://tinyurl.com/yeyuxkze for more details].

[81] See https://tinyurl.com/2sappv7u for a recent analysis.

[82] See https://bit.ly/40VdeAW.

[83] See https://mck.co/3KyvHhx.

[84] FAA's "for-credit" equipment qualification tests many components of the vehicle including flight control computer, high-voltage manual disconnect switch, electronics ventilation computer, vehicle sensor computer, etc. These are facilitated by pilot on-board vehicle flying tests. Joby has begun "for-credit" flight tests with its production vehicle S4 this past year of 2023 while Archer is expected to begin the same with its Midnight production flight sometime during this year in 2024.

[85] 14 CFR Part 21 defines three stages of certifications: type (TC), production (PC), and airworthiness or operational (OC). TC is the approval of the design of the aircraft and all component parts including propellers, engines, control stations, etc.. TC signifies the vehicle design is in compliance with applicable airworthiness, noise, fuel venting, and exhaust emissions standards; PC is the approval to manufacture duplicate products under an FAA-approved TC. It signifies that an organization and its personnel, facilities, and quality system can produce a product or article that conforms to its approved design; and finally, OC is necessary for operation of civil aircraft that can be either in the Standard or Special class signifying that an aircraft meets it's approved TC (if applicable) and is in a condition for safe operation [See http://tinyurl.com/yc7p5t8c for more details].

[86] https://bit.ly/4117bek.

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.[87] Later in March 2022, Joby submitted its first area-specific certification plan to the FAA (i.e., 3rd stage of TC process), 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".[88] In submitting to stage three of TC process, Joby submitted a dozen Area-Specific Certification Plans (ASCPs) covering both hardware and software aspects of every system onboard the five-seater eVTOL aircraft, including its flight controls, energy storage and distribution system, and propulsion system. In addition to submitting all of ASCPs, as expected, Joby also submitted other Certification Plans comprising the third stage of its aircraft type certification program,[89] including detailed plans for aircraft cybersecurity and systems safety. Towards the end of last year (2023), Joby completed a series of tests with FAA's Office of Airports and Technical Operations, to support the work defining the design criteria for skyports. On November 12, 2023, Joby also performed an exhibition test flight out of NYC's downtown Manhattan heliport. Volocopter did the same the day after. These demonstration flights were meant to improve community acceptance. Having unveiled its production aircraft Midnight in November, 2022, Archer is in the process of finalizing its Means of Compliance (MOC) this past year leading towards TC by this year of 2024 as well.[90]

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 February 2024, Joby and Archer received Part 145 repair station certification from the FAA, which will allow the OEMs to perform select maintenance, repair, and overhaul (MRO) services on its air taxi and conduct full MRO operations following type certification[91]. With FAA's acceptance of propulsion certification plan of Joby in February 2024 all structural, mechanical, and electrical system certification plans now accepted by FAA.[92] In 2022, Joby also applied for its eVTOL aircraft to be certified for use in the United Kingdom and in Japan. In February, 2024, Joby announced agreement with United Arab Emirates (UAE) providing Joby with the exclusive right to operate air taxis in Dubai for six years starting entry into services in 2026. The agreement secures a variety of support from the Dubai's Road and Transport Authority (RTA) including financial mechanisms, for entry and maturing of service operations in Dubai.[93]

There is also eVTOL TC progress globally. On October 13, 2023, the Civil Aviation Authority of China (CAAC) issued a Type Certificate (TC) to EHang's autonomous

[87] https://bit.ly/3KzFTq6.
[88] https://bit.ly/3ZFA1Qi.
[89] Broadly speaking, there are 5 stages in TC: Certification basis or Stage 1; Means of Compliance or Stage 2; Certification plans or Stage 3; Testing and analysis or Stage 4; and finally, Show and verify in Stage 5. Having worked through the first 3 stages, according to Joby, it is now concentrating more on the later two stages.
[90] For an analysis of certification stages and EIS in the US, see https://tinyurl.com/5n7yzbvy.
[91]See http://tinyurl.com/msyp634k
[92] See http://tinyurl.com/nbx28ffa
[93] See http://tinyurl.com/5f3uht3j for more details.

EH216-S, the first of its kind.[94] 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).[95] German air taxi manufacturer, Volocopter, obtained a production organization approval (POA) from the European Union Aviation Safety Agency (EASA)[96] 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 this year in 2024 and plan to fly during the 2024 Paris Olympics, and 2025 EXPO Osaka Kansai.[97] 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.[98] 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.[99] Airbus expects its UAM aircraft to meet EASA certification standards (EASA SC-VTOL Enhanced Category) and receive TC around 2025.[100]

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*.[101] 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) Inter-Agency Working Group (IWG) 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 IWG 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

[94] See http://tinyurl.com/53b2mac6.

[95] Eve Urban Air Mobility, an Embraer company, went public through a merger with a special purpose acquisition company (SPAC) in May 2022, 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.

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

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

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

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

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

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

plans within different LOBs of the FAA including AAM CONOPS[102] will complement the national strategy. IWG's national strategy is expected to be complete by the middle of this year in 2024.

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, including recently completed work that is now publicly available.[103]

This research was divided into 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.

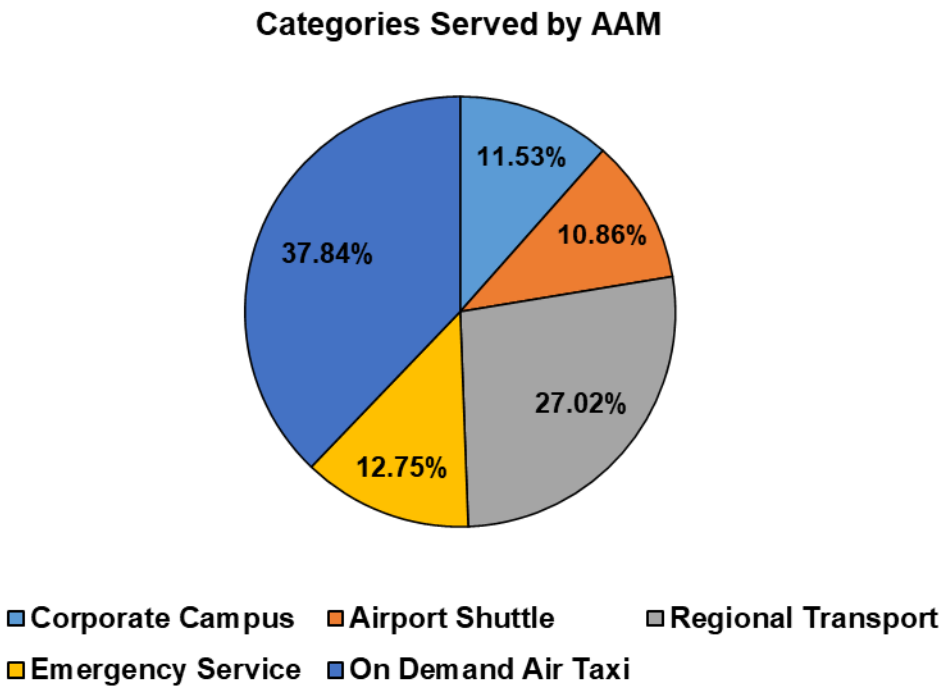
The emergence of AAM will likely bring about a variety of new services in five distinct market segments, including airport shuttles, regional air mobility, on demand air taxis, corporate campus shuttles, and emergency services. Some of these services, particularly regional transport, may be served by eVTOLs as well as short take-off and landing (STOL) and conventional take-off and landing (CTOL) vehicles.[104] FAA-sponsored research[105] research broadly defines the following categories of services or missions that will likely be served by AAM and their anticipated market share distribution:

[102] For the version 1.0, see https://go.nasa.gov/3ZJASzr. Version 2.0 of FAA's AAM CONOPS was released in April, 2023 and available at http://tinyurl.com/53b2mac6.

[103] See https://bit.ly/3U60IfX; and https://tinyurl.com/ylcqlaqt completed research and more details.

[104] 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).

[105] See https://tinyurl.com/23zuwhzt for more details.



Airport shuttles and similar fixed-route passenger services are the most likely AAM passenger services to gain economic tractions in the coming decade.[106] On demand air taxi is likely soon follow. Optimistic reports project the AAM passenger industry to have 23,000 aircraft with 740 million enplanements per year at a price of around $30 per trip by 2030.[107] 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 KPMG predict 60.4 million enplanements by 2030 and a much smaller industry size.[108] Similarly, Roland Berger estimates a fleet of only 12,000 passenger eVTOL aircraft by 2030 serving much smaller total passengers.[109] 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-

[106] 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 followed by remote supply, 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]. For FAA's ongoing sponsored research by ASSURE in some of these areas, see https://tinyurl.com/yloeynhd.

[107] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. [See http://tinyurl.com/m9jb7yrx; and http://tinyurl.com/yeyuxkze for more details

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

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

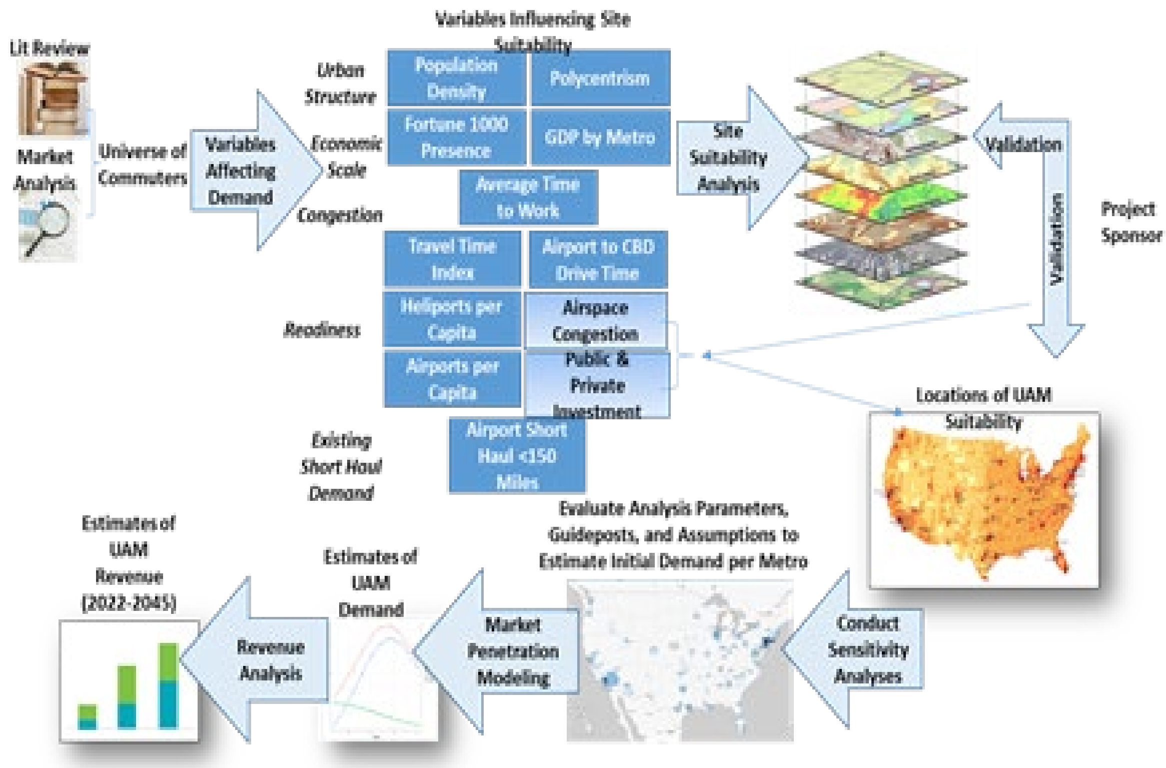
seater aircraft in the US. Baselining in this most conservative scenario, these services may yield an annual market valuation of $2.5 billion.[110]

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. The FAA sponsored research to develop a framework, called site suitability analysis, to analyze demand triggers leading to likely deployment to initial sites that will be served by AAM. This research[111] 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,[112] economic scale is represented by presence of fortune 100 companies and gross regional product or gross domestic product (or GRP or GDP, respectively) 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:

[110] 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].

[111] Urban Air Mobility Studies, available here: https://tinyurl.com/23zuwhzt

[112] 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.

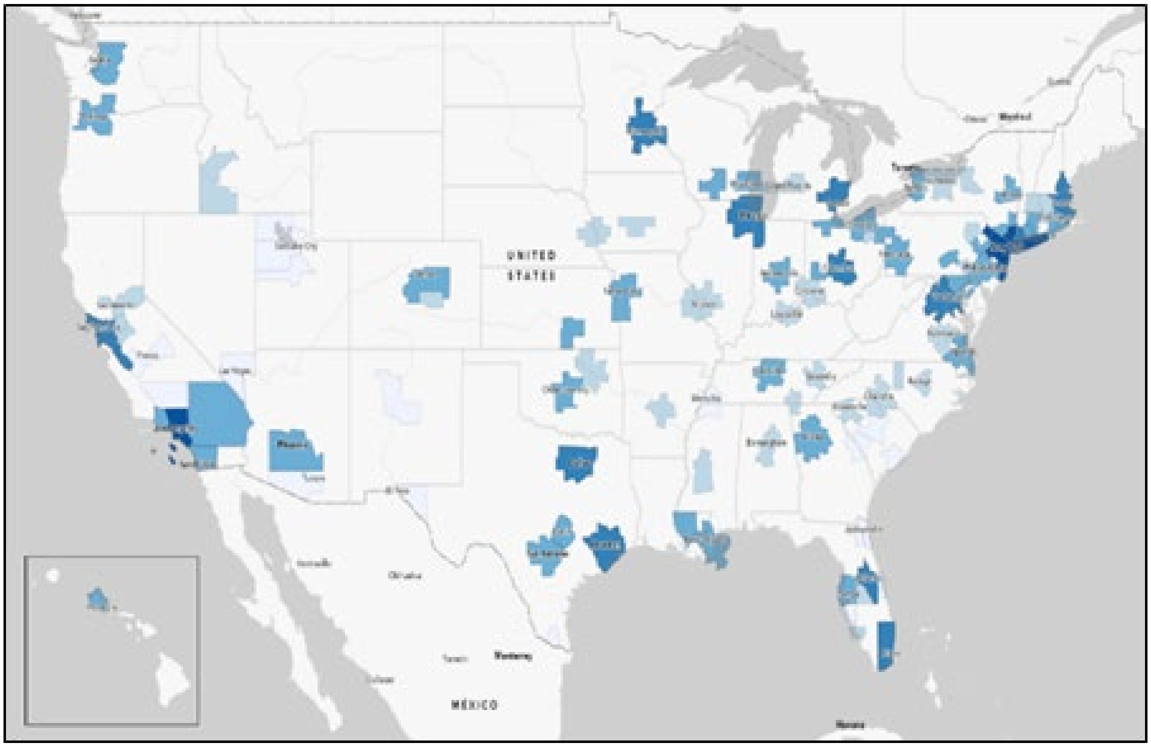


Site Suitability Framework

Assigning weights[113] to the variables within the broad five categories and using the above site suitability analysis framework, this research identifies the following 100 metro areas for likely AAM services:[114]

[113] 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.

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



Site Suitability Analysis Results

Matching the above metros against the expressed interests of the AAM OEMs and likely operating partners, mostly gathered via public statements, this research identifies the following 5 likely areas of initial operations:[115]

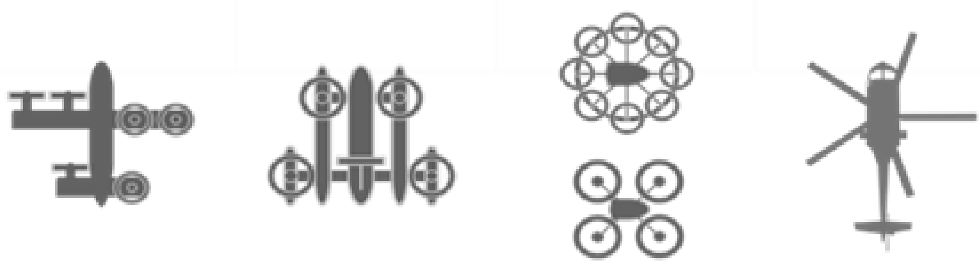
Lauch City	Original Equipment Manufacturer and Operating Partners
Orlando, FL	Lilium (2024)
New York City, NY	Blade with BETA (2024-2025), Halo (2026), Archer and United (2025), Joby and Delta (no date yet)
Los Angeles, CA	Archer (2024), Joby and Delta (no date yet)
Marina / Santa Cruz, CA	Joby (no launch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

[115] 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.

Broadly speaking, there are four types of AAM aircraft that are likely to enter into services, according to the research. These are aggregated into following 4 categories: [see Figure 3.2 (p. 154) Urban Air Mobility Studies, available here: https://tinyurl.com/23zuwhzt]:

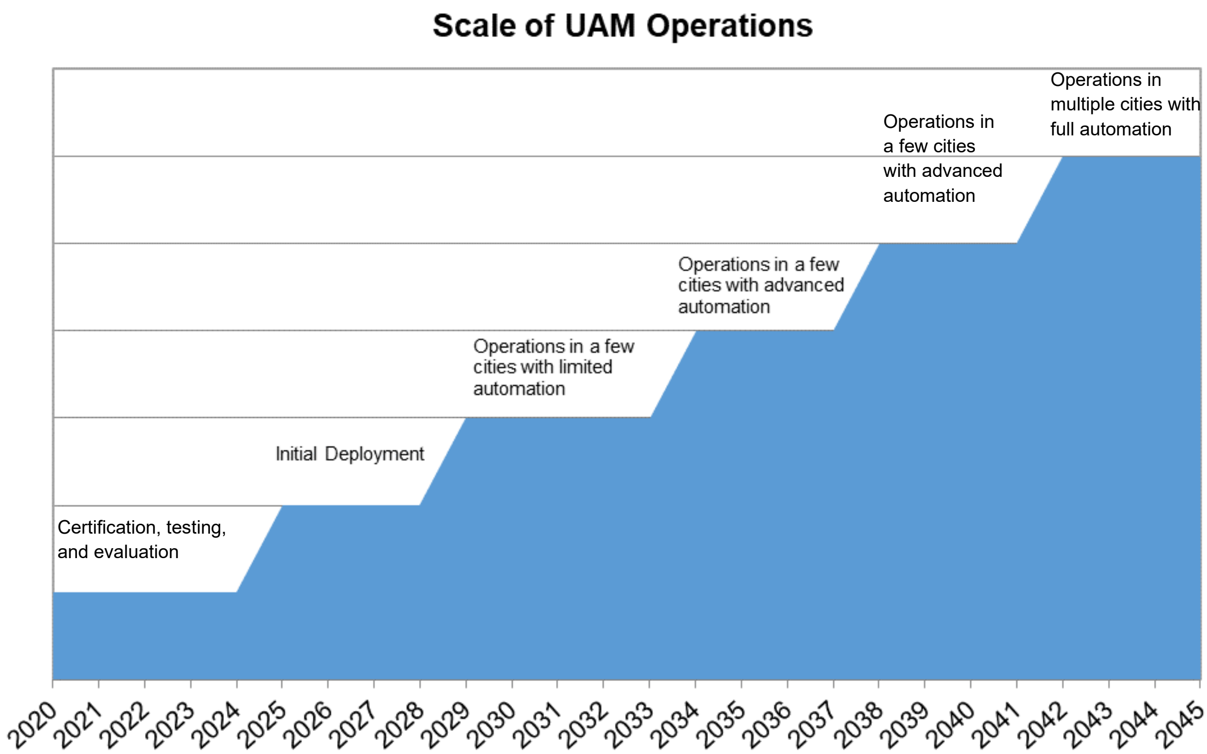
Vehicle Architecture Characteristic

Vectored Thrust	Lift + Cruise	Wingless Multicopter	Electric Rotorcraft
An aircraft that uses **any** of its thrusters for lift **and** cruise	An aircraft that has **independent** thrusters for lifting and cruising	An aircraft that is **only** equipped with **lifting thrusters**	An aircraft that utilizes a single lifting rotor (electric helicopter or electric autogyro)



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)].



Based on the research performed by numerous others noted above and throughout this document, the FAA believes that AAM will likely enter into services (EIS) sometime around 2025-2027. 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 integration;
- 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 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 or airworthiness certifications; and,
- Meeting other broad local, state, and federal regulations.[116]

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 challenging and somewhat hypothetical and

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

arbitrary.[117] Nevertheless, drawing from FAA-sponsored 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 hypothetical years of 1 through 6[118] in the table below:

	Departure Forecasts*					
	Year1	**Year2**	**Year3**	**Year4**	**Year5**	**Year6**
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 this projection is used in preparation of NPRM for Powered-Lift NPRM published in June of last year.[119] 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.[120] 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 can carry four passengers

[117] As reported throughout this document, the FAA routinely forecast sectors (i.e., crewed and unmanned 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. 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.

[118] Many in the AAM community identifies 2025-2027 as likely point of entry in time [see https://tinyurl.com/5n7yzbvy for an analysis] 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 2025-2027 or soon thereafter. Furthermore, we keep the forecast horizon short to Year 6 afterwards 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.

[119] 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.

[120] 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.

and a pilot.[121] In December 2022, the proposed airworthiness criteria for the Archer Midnight aircraft was published in the Federal Register by the FAA.[122] 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's Midnight eVTOL prototype made its first untethered hover flight test on October 25, 2023.[123] The Midnight is a four-passenger, piloted aircraft that can fly up to 100 miles on a single charge. Archer expects the Midnight to be able to perform multiple 20-mile flights after only 10 minutes of charging. This aircraft will be used to enable testing in advance of "for credit" certification testing.[124]

The regulatory landscape is evolving to accommodate AAM into service. For example, the FAA has proposed a Special Federal Aviation Regulation (SFAR), 'Integration of Powered-Lift: Pilot Certification and Operations,[125] to establish temporary operating and pilot certification regulations for powered-lift. With an approach to set initial requirements while allowing the FAA to gather additional information towards determining the most appropriate permanent rulemaking, the SFAR complements other rulemaking activities that are already in place. For example, the SFAR is integrated with aircraft certification activities currently underway, other policy development and operational certification efforts in support of AAM planned EIS. The SFAR would allow powered-lift operations to begin while the FAA collects data needed to establish permanent regulations. The FAA published SFAR NPRM in June, 2023 in time for one or many powered-lift aircraft's expected certification.

To account for impending uncertainties, only two scenarios that are comparable and drawn from FAA-sponsored research projections, base and low forecasts are reported in the table above.[126] Given the Entry Into Service (EIS) in Year1-2, 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. 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 Year 6), 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 Year 2. It may likely reach around 2.7 million by end of the projection in Year 6.

Using the distribution of AAM missions mentioned above, we anticipate these aggregate departure projections to start with airport shuttle, 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 around 60

[121] https://bit.ly/40GnUno.
[122] See https://bit.ly/436vucv for more details.
[123] See http://tinyurl.com/2sz4xmmb.
[124] See https://bit.ly/40M1Nfh for more details.
[125] See https://bit.ly/3Mi3f4O for more details.
[126] 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 these initial projections.

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[127] and load factors (i.e., number of revenue passengers per departures). Taking these into consideration,[128] assuming low load factors (e.g., 2-3 passengers per departures for lower and base cases, respectively),[129] number of passengers corresponding to departure scenarios may be calculated and are reported in the table below:

	Passenger Flow* Corresponding to Departures					
	Year1	**Year2**	**Year3**	**Year4**	**Year5**	**Year6**
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 Year 2 in the base case scenario or risk-adjusted potential scenario. In lower range, passenger levels may reach cumulatively over 1 million passengers by Year 2 driven by assumptions of lower number of departures and load factors.

Translating the above annual numbers to daily departures/passengers (e.g., total de partures 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 Year 1. 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 Year 2. 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 Year 6.

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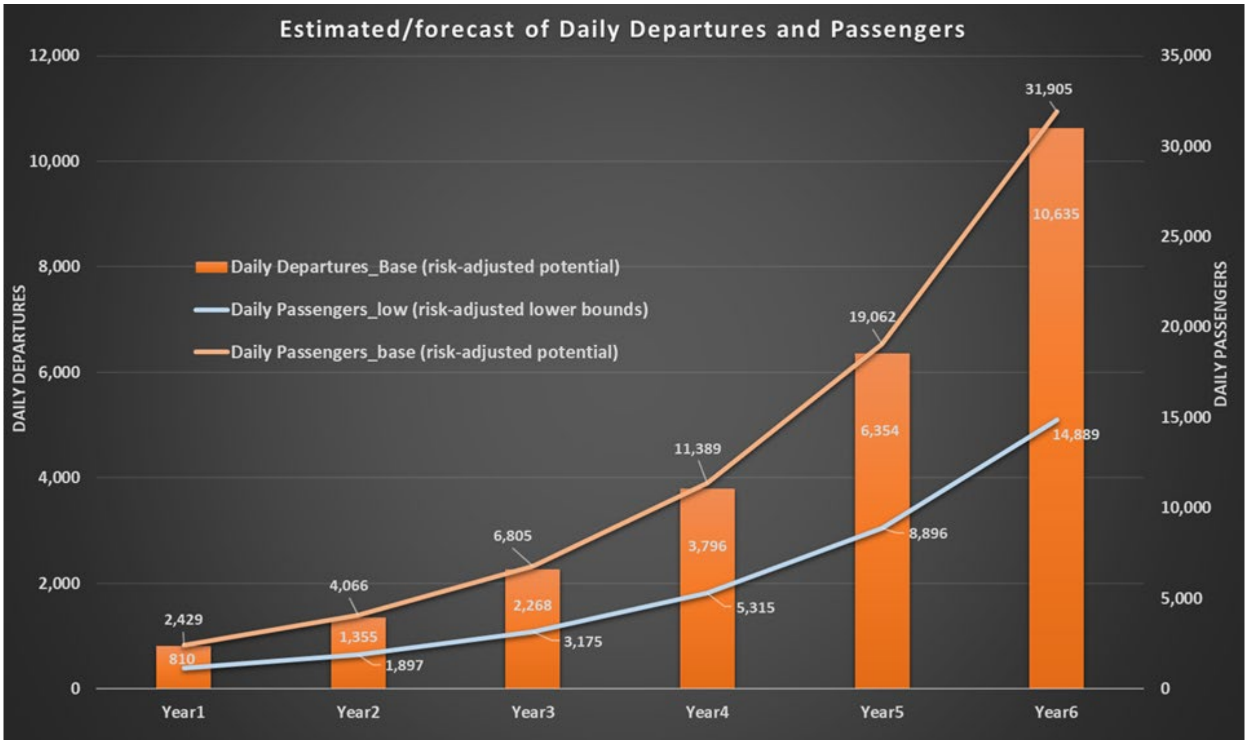
[127] For a discussion on these issues and their impact on AAM business cases, see https://bit.ly/40CbOvs.

[128] It is not conclusive to what extent lower overall load factors (e.g., dead-heading back from revenue missions) and lower utilization will impact 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.

[129] 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[130], 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.[131] 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.[132] In addition, there are over 9,000 commercial helicopters in the US.[133] All of these may likely provide strong

[130] There seems to be two paths developing in battery technologies crucial for recharging. For example, while Joby announced it will be using company's own Global Electric Aviation Charging System (or GEACS; see https://tinyurl.com/app], Archer has decided to use BETA's interoperable and multimodal fast-charging system, which employs the Combined Charging System (CCS) utilized by top OEMs in the electric aviation industry [see http://tinyurl.com/37a2f4jx]. Both announcements came in November, 2023.

[131] 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.

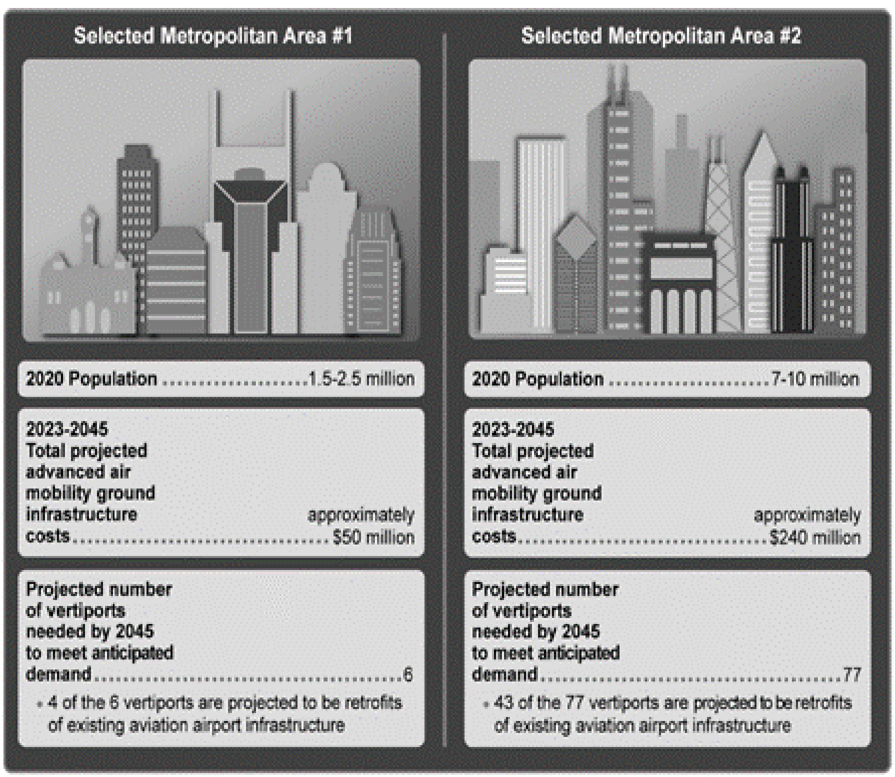
[132] https://bit.ly/3m0vfPL.

[133] 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)[134] 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:[135]

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,

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

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

both Joby and Archer entered into partnerships with parking garage operator REEF Technology with the goal of running air taxi operations from the rooftops of redesigned parking garages.[136]

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.[137] 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.[138]

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, Archer, BETA, and Joby announced in January, 2024 collaboration with Atlantic Aviation to electrify several of Atlantic Aviation's existing aviation assets to support future electric aircraft operations, including at Atlantic Aviation locations across four key launch markets of New York, Los Angeles, Miami, and San Francisco.[139] In similar vein, Clay Lacy Aviation announced a partnership with Joby Aviation in January this year.[140] In Germany, airport operator Fraport and the OEM Lilium N.V., announced recently in January, 2023 their strategic collaboration to explore required planning and approval steps for state-of-the-art infrastructure for the implementation of commercial eVTOL operations at airports. In particular, Fraport and Lilium plan to analyze future mobility concepts for vertiport networks that are suitable for serving eVTOLs. Although Germany is the focus at present, Fraport is active at 30 international airports across four continents, and therefore, infrastructure improvement may spread to other areas as well.[141] 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.[142] 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. Ferrovial has been developing a network of 10+ vertiports across the state of Florida in the US and a network of 25 vertiports across the

136 https://bit.ly/3ZHz2io.
137 https://go.nasa.gov/40RxJi2.
138 See https://bit.ly/4351vBK for more details.
139 See https://tinyurl.com/ypgbu5qx and https://tinyurl.com/ylr3vv3t. Atlantic Aviation is a fixed-base operator or FBO.
140 Emerging collaborations of AAM OEMs with FBOs are interesting for two reasons: first and foremost, FBOs have customer base in cities that OEMs will be interested in; and second, they also have existing infrastructure that AAM OEMs can use readily. However, distance from FBO terminals to commercial airport terminals, for airport shuttle service in particular, may be a huddle that AAM OEMs have to address.
141 See https://tinyurl.com/ypzua6tr for details.
142 https://bit.ly/3MkTaUy.

UK. In the UK, Ferrovial has partnered with property developer Milligan to identify potential vertiport sites.[143]

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.[144]

Finally, there is also Congressional support in developing AAM infrastructure. The Advanced Aviation Infrastructure Modernization (AAIM) Act was passed by the US House of Representatives on June 14, 2022.[145] 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[146] 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.[147] 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.[148] 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.[149]

In comparison, ASSURE estimated revenue to be modest; at around $150 million in

143 See http://tinyurl.com/4kdymbc5

144 See ACRP Report #243: Urban Mobility: An Airport Perspective (2023); available at https://bit.ly/3U95DfU.

145 See https://bit.ly/3ZBg9xP.

146 See https://bit.ly/3zwB6PL for more details.

147 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]

148 https://bit.ly/3Ku0xaV.

149 See Morgan Stanley's eVTOL/UAM TAM Revenue in 2050; Base case only; See https://mgstn.ly/35JTCnv.

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[150] 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.[151]

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.[152] Socioeconomic and spatial 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.[153] Additionally, eVTOL operators like Joby are expanding partnerships to operate air taxis in international markets[154] and many companies are experiencing rising interest and increased orders of their eVTOL aircraft, both in the US and globally.[155] However, as the capital markets tighten with successive rises in federal funds rate,[156] securing capital would become challenging and making business cases for

[150] 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, 2023. 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].

[151] 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.

[152] 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 2022 of workers (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.

[153] https://bit.ly/3mbpoHd.

[154] https://bit.ly/40ZbBCf.

[155] 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.

[156] See https://bit.ly/3KyjN7e.

AAM more demanding. According to McKinsey & Company, the broad industry[157] 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.[158]

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.[159] The FAA also issued a concept of operations (CONOPS) in June 2020,[160] 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.[161]

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,[162] AAM playbook,[163] high-density vertiplex,[164] regulatory coordination for safety, traffic management, and international harmonization with other agencies, e.g., European Union Aviation Safety Agency (EASA) leading to type certifications.[165]

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.[166]

In November 2022, Archer and United Airlines announced first commercial electric air taxi route in the US: from southern tip of Man-

[157] Includes sustainable aviation using hydrogen cells, supersonic aircraft, passenger eVTOL aircraft, surveillance and cargo drones.
[158] For a partial list of passenger eVTOL A/Cs orderbook at the end of December, 2022, see https://bit.ly/3ZBwSRD.
[159] See https://bit.ly/3nKJLeR.
[160] Available here: https://go.nasa.gov/3GjrcEV. Revised version (2.0) is expected this spring.
[161] See https://go.nasa.gov/3Kykopu for more details.
[162] See https://go.nasa.gov/3MgSyza.
[163] See https://go.nasa.gov/3mcXz15.
[164] See https://go.nasa.gov/3KxT5LS.
[165] See, for example, https://bit.ly/40YxuBU.
[166] https://bit.ly/3KxNgyd.

hattan to Newark Liberty International Airport.[167] 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[168] 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.[169]

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.[170] 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 commercial service, expected to start in Singapore by 2023.[171] 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, and eventual community acceptance leading to greater adoption. Future AAM operators are also expected to comply with new operating requirements and other regulations in the near future. In addition, cash liquidity for continues to be a key concern going into 2024. McKinsey reported that the eVTOL market segment in 2023 received only half the funding it did in 2022. One McKinsey analysis revealed the cash runway for five western publicly traded eVTOL companies to be "less than one year for some and slightly more than three years for others based on their current and projected cash burn rates and revenues". [172]

Yet, the evolving AAM manufacturing landscape looks very promising. For example, as reported last year, agreements of Archer with Stellantis, Lilium with GKN Aerospace, and Joby with Toyota[173] to mass produce aircraft

[167] https://bit.ly/3UgPjtO.
[168] https://bit.ly/3MgSXBG.
[169] 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.
[170] https://bit.ly/3U6ERoB.
[171] https://bloom.bg/3m9Tj2o.
[172] http://tinyurl.com/45j5fj9y
[173] https://cnb.cx/3Gd4Rcb; https://bit.ly/3ZJki2u, and http://tinyurl.com/4r8dy4ya, respectively.

indicate that the OEMs have positioned post TC stages to production and routine operations. For example, Joby's S4 is to be produced at Dayton, Ohio.[174] In September, 2023, Joby also delivered its first production vehicle to Edwards Air Force base.[175] With a secured construction loan of $65 million from Synovus Bank, Archer in collaboration with Stellantis, have finalized standing up manufacturing facility of 350,000 sq. ft. in Covington, Georgia, to begin producing 650 Midnight four-passenger eVTOL aircraft/year in 2024.[176] 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.[177] 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.

Sensing the forthcoming opportunities, state, local, and regional governments are aligning themselves with the manufacturers and likely operators. For example, the state of Ohio provided a $93 million job creation tax credit to Joby for setting up production facility at Dayton[178] while receiving $9.8m CalCompete grant supporting expansion of manufacturing footprint in its existing facility at Marina, CA.[179] Furthermore, 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 and broader uses during Olympics games in 2028.[180] In August 2022, Ohio published its first AAM framework.[181] 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.[182] Other entities, including the Canadian AAM Consortium (CAAM) have also studied the impacts of AAM on regional economies.[183]

Other supporting facilities through collaborations are emerging as well. For example, in November 2023, NASA and USAF AFWERX announced partnership seeking to define and perform initial integration of an AAM Operations Center. The AAM Operations Center is intended to be both scalable and tactical, capable of verifying all of the systems and sensors that go into UAS, eVTOL, and other emerging aircraft designs. The initial

[174] See https://tinyurl.com/yw7ab3uk.
[175] See https://tinyurl.com/yulbmbf3. Exchanging data and sharing capabilities and expertise for testing these emerging technologies in AAM, FAA is partnering with the Air Force to safely integrate AAM into the NAS. See http://tinyurl.com/57jnhfk7 for more details.
[176] See https://bit.ly/3nAmdZV.
[177] See https://bit.ly/3zSIQMI for more details.
[178] http://tinyurl.com/mryefsf5
[179] http://tinyurl.com/59ckmnyd
[180] https://bit.ly/3Kymiq8; see also https://bit.ly/3Gj9Tnw.
[181] https://bit.ly/4335Q8t.
[182] https://bit.ly/3U9abD2.
[183] https://bit.ly/3Kygo8o.

AAM Operations Center will be built out in collaboration with NUAIR at the Syracuse Hancock International Airport, with an aim to test and transition it to additional locations by 2025.[184]

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.[185] Furthermore, targeting investments 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.[186]

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 2025-2027 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.

[184] http://tinyurl.com/yeyndnm3
[185] See https://go.nasa.gov/433wFJQ.
[186] See https://go.nasa.gov/3m9Ulvi for more details.