Unmanned Aircraft System and Advance Air Mobility

New Entrants: Analysis and Forecasts

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

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

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 Section 349 of that Act repealed the Special Rule for Model Aircraft (section 336 of Pub.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

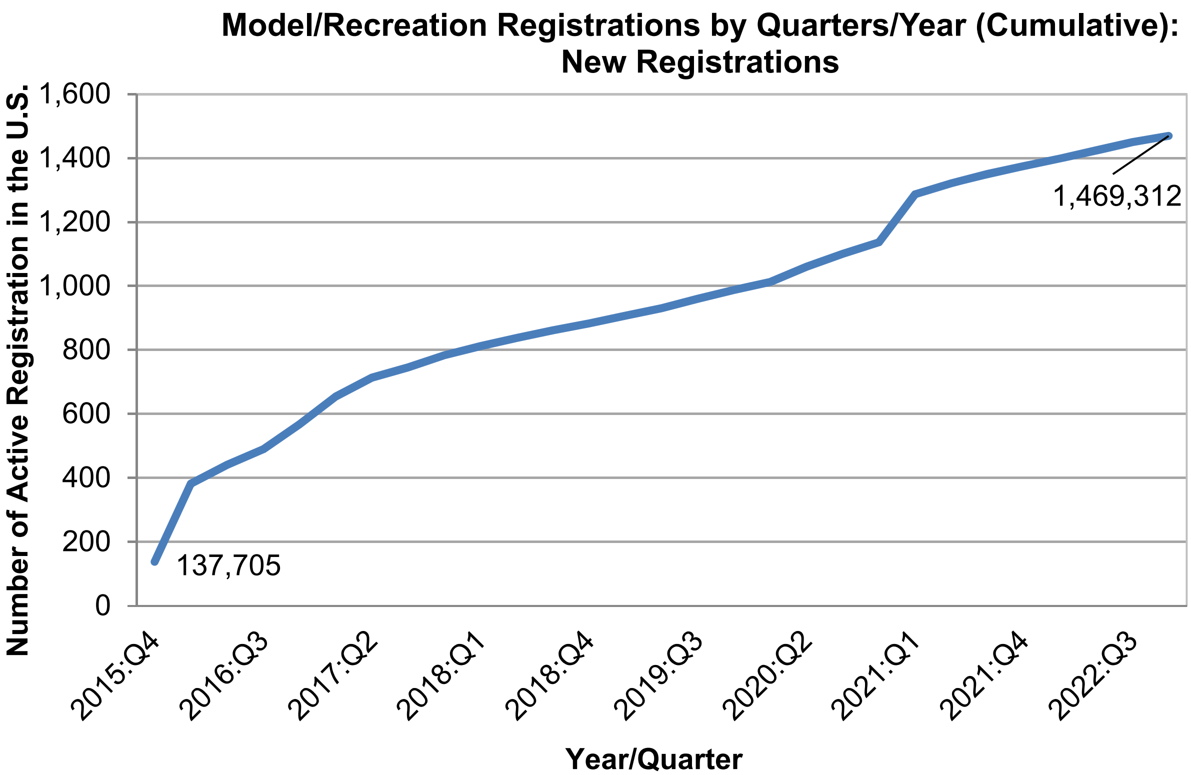
from FAA sponsored and other research, government and industry reports.

Trends in Recreational/Model Aircraft New Registration

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

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

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



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

Forecasts Using New Registrations vs. Effective/Active Fleet

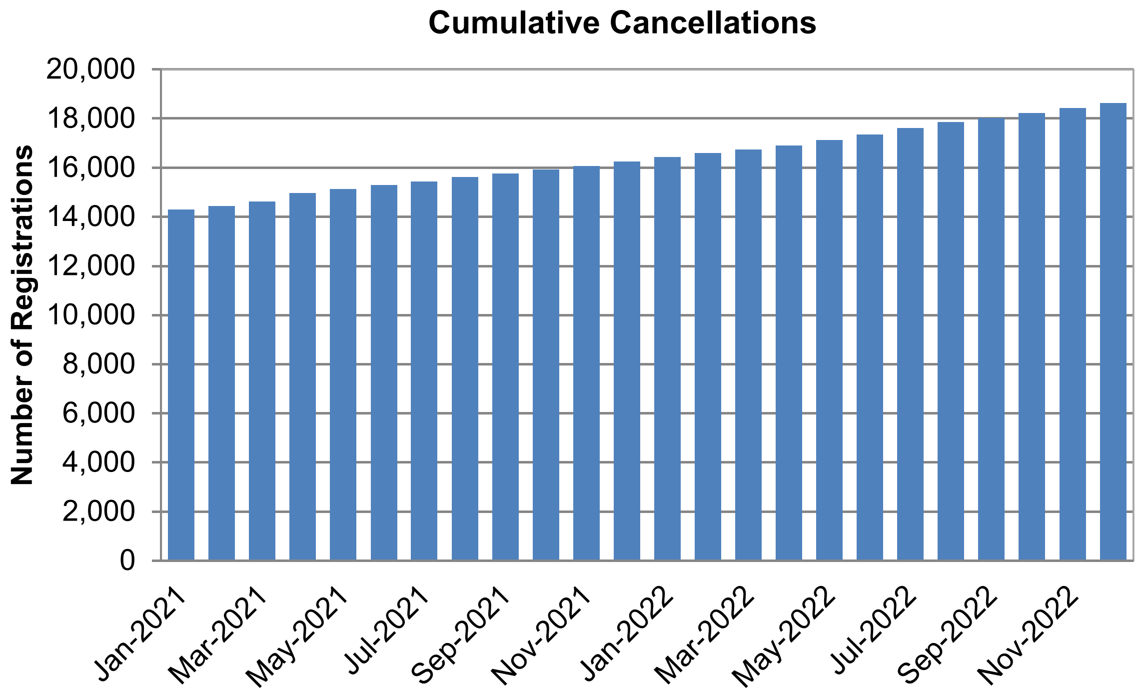
As noted in earlier Aerospace Forecast reports, small drones are registered for 3 years while remote pilot (RP) certifications are valid for 2 years.[14] Following the Taylor vs. Huerta ruling and the FAA's authority over registration via NDAA, the Agency elected to extend the registration period, for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

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

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

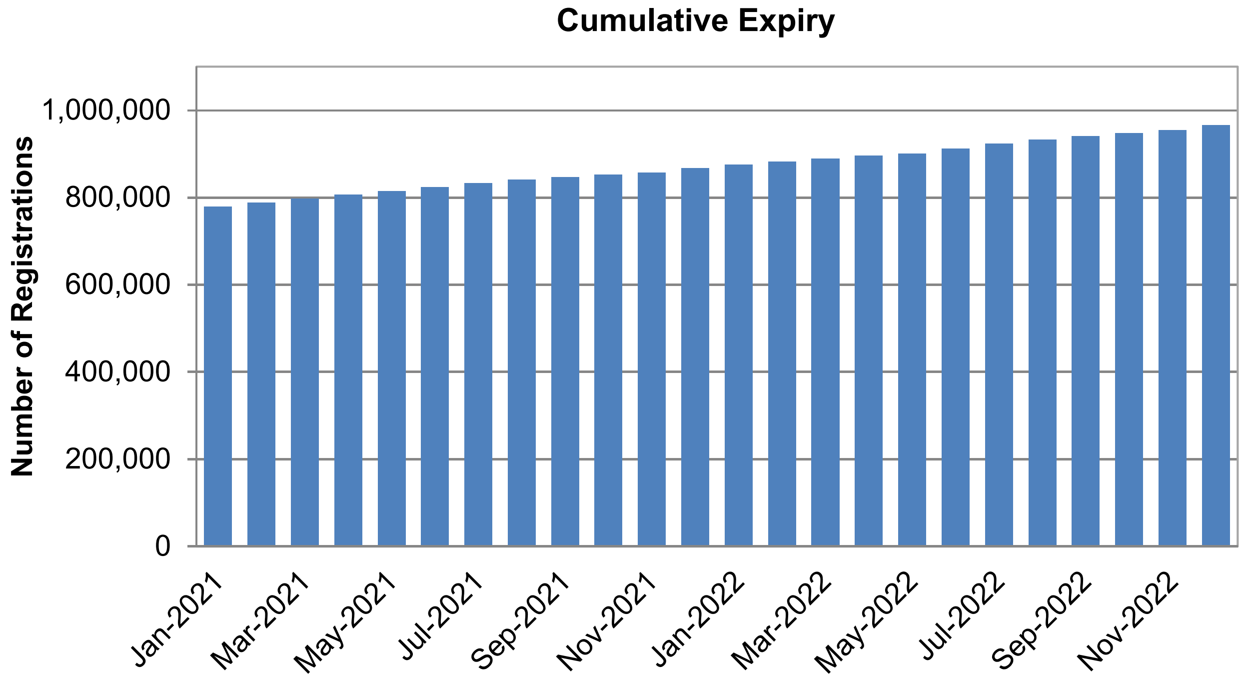
[14] See https://bit.ly/2IfJ1cm; and https://bit.ly/2AUacmT

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

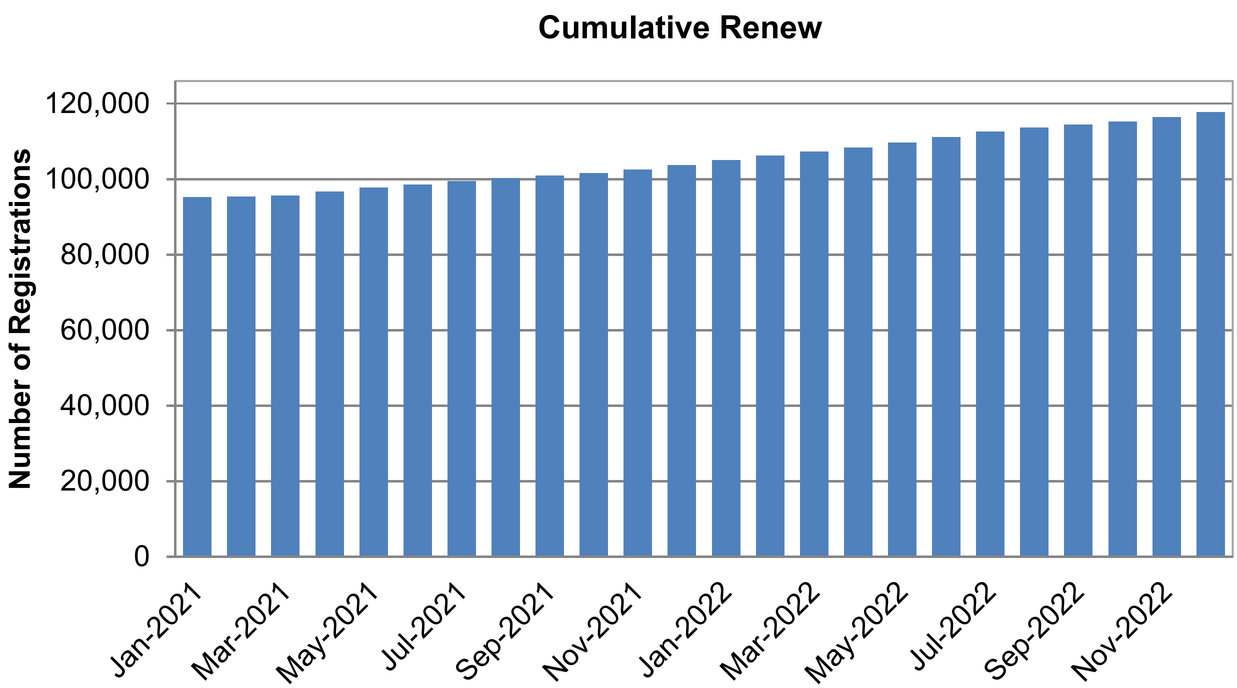


We extend the data by one more year this year and observe that trend in cancellations remain the same as reported last year; cumulative cancellations, on average, stood at around 15,313 with new monthly cancellations at 179 during January-December, 2021. These numbers are comparable to what we observe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

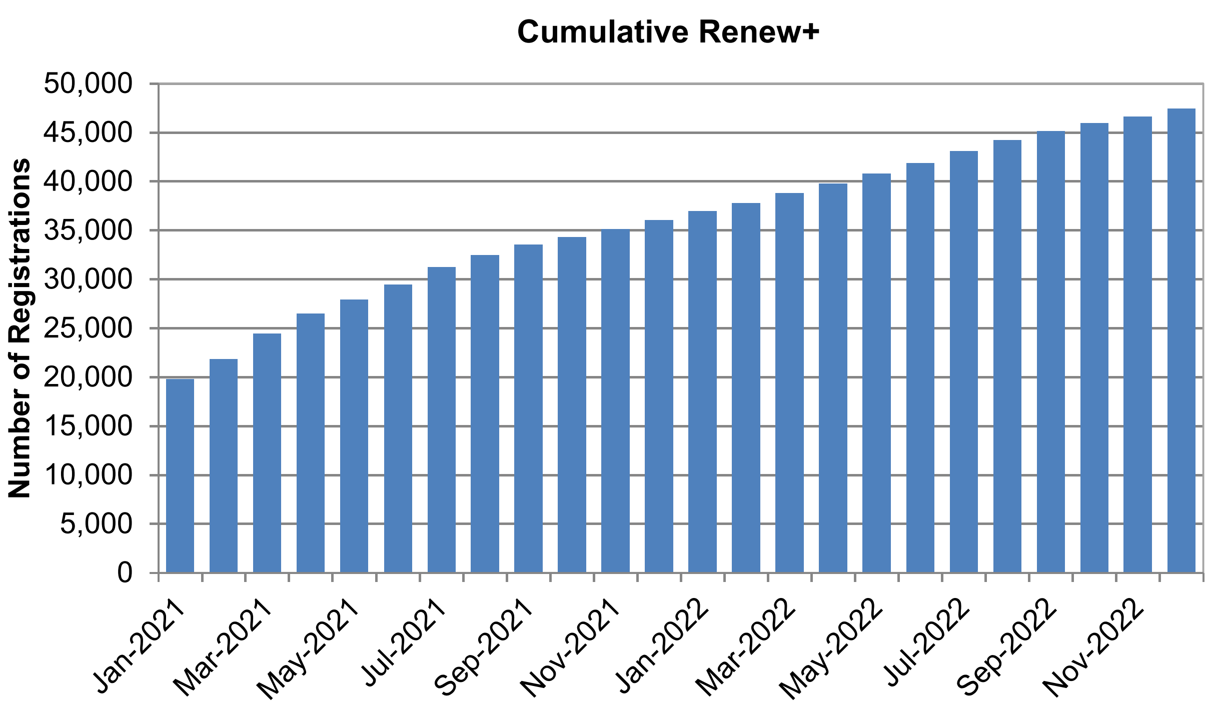
On average, cumulative registrations expired at a rate of more than 825,000/month following the immediate and substantial adjustment in December 2020, as noted above and as shown below. This is equal to a little more than 8,192 new average expiries for each month during January – December 2022; during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



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

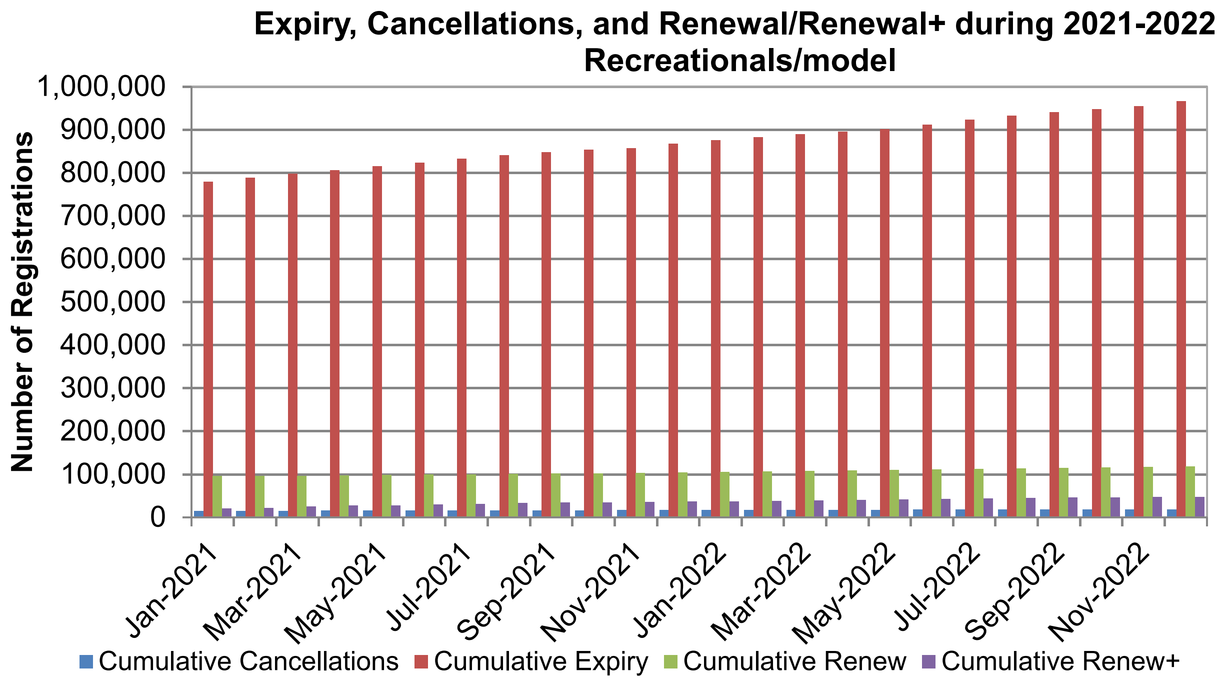


Renew+, re-registrations after expiry date, logged on cumulative average of 42,369/month during January-December, 2022. This is equivalent to approximately 950 new average Renew+ registrations for each month during January – December 2022 and are reported in below:



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

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



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

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

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

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

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

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

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

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

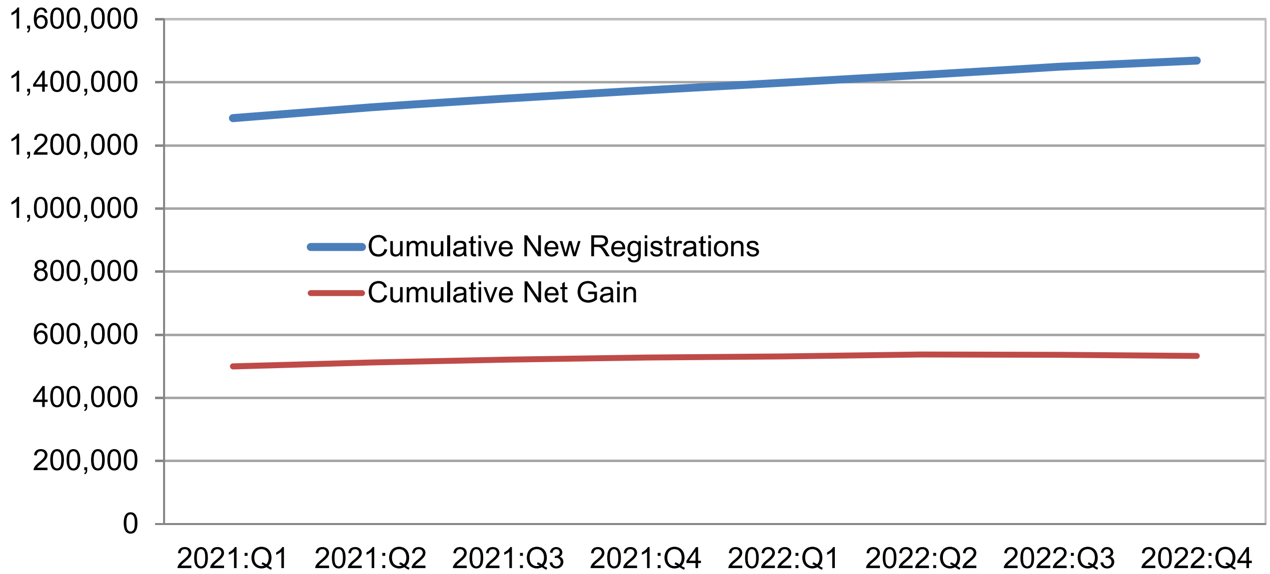
[18] It is important to note here that renew+ is a replacement for cancellation on a one-on-one basis.

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

32 X (+1) = -12

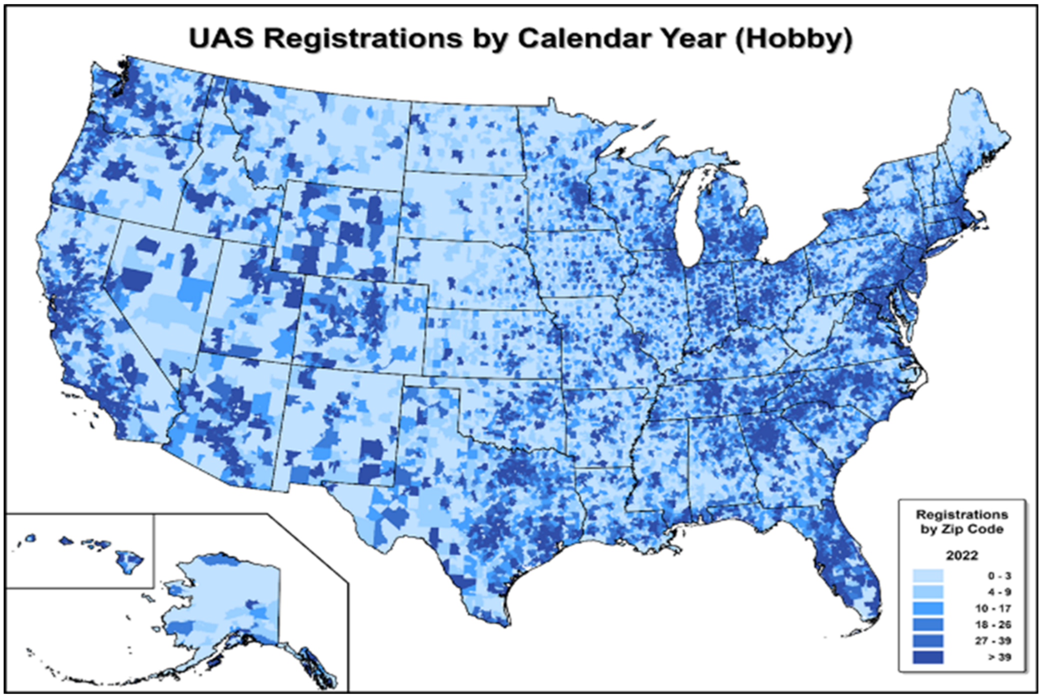
Finally, a comparison chart capturing the difference between cumulative new registrations and. effective/active registrations, using cumulative net gain/loss for recreational registrations, is provided below covering the entire period of 2021-2022:[19]

New Registrations versus Net Gain (cumulative): Model/Recreational



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

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



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

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

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

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

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

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

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

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

Total Recreation/Model Fleet (Million sUAS Units)

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

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

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

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

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

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

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

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

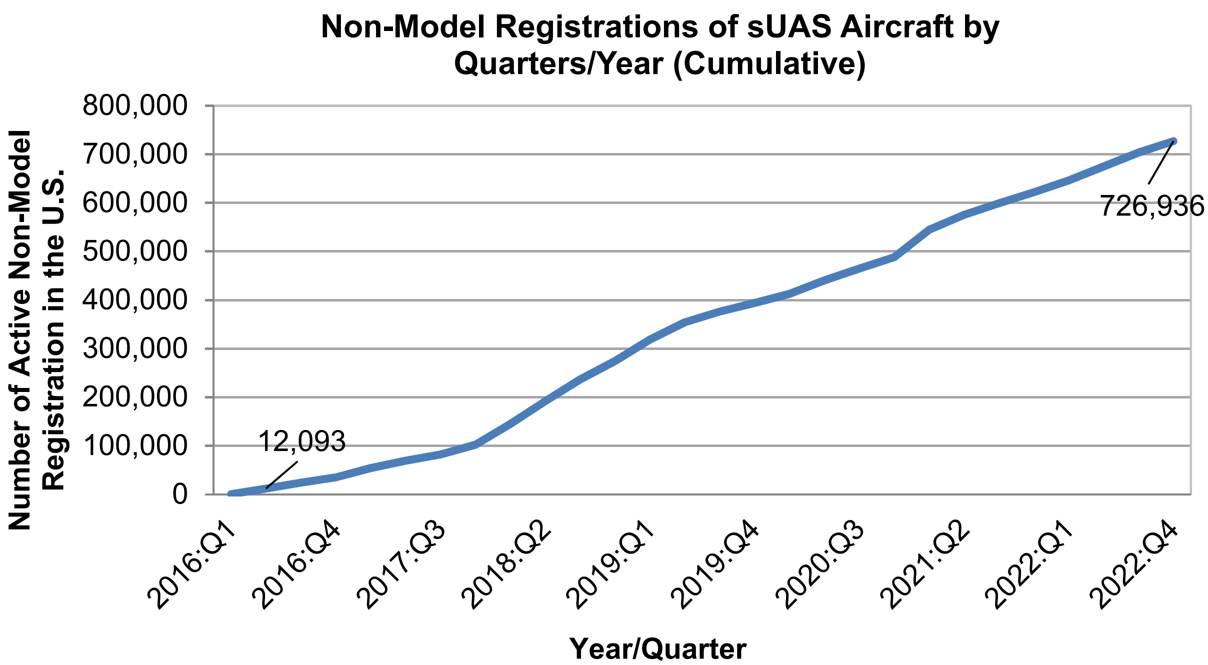
The Recreational UAS Safety Test (TRUST)

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

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

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

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



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

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

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

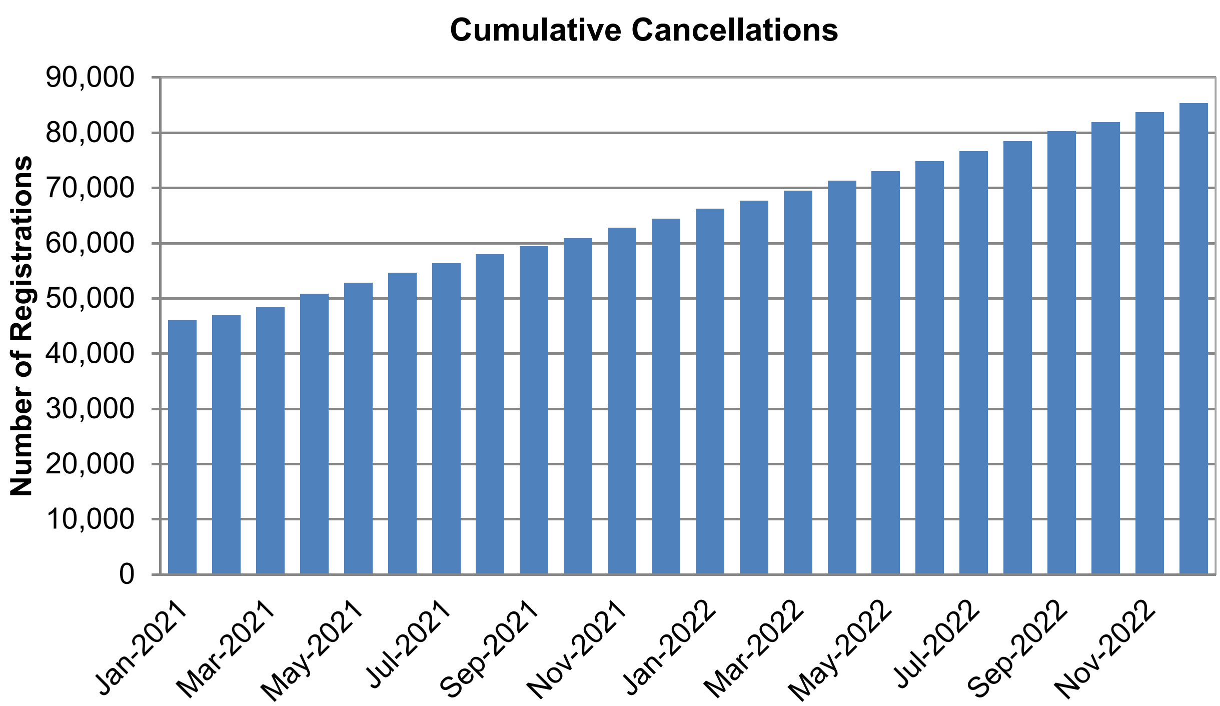
Together, these rules provide much-needed regulatory clarity and reduce the need for waivers under Part 107. With enhancement of operational efficiencies under increasingly well-defined concepts of operations (CONOPS)—which ensures safety and transparent information flow across the community—more and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

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

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

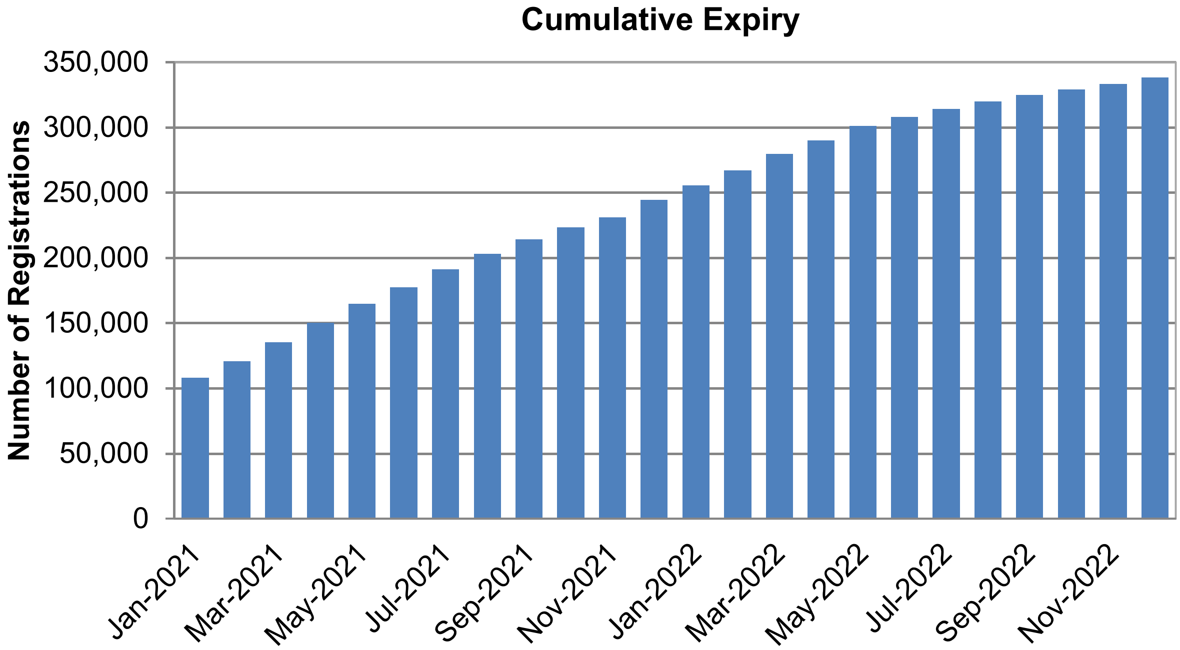
As noted in the preceding section, the beginning of the registration renewal afforded the FAA an opportunity to review Part 107 data; duplicates and unnecessary registrations were removed, and the registration database was made cleaner and more compact. As in the case of recreational/model aircraft,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

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

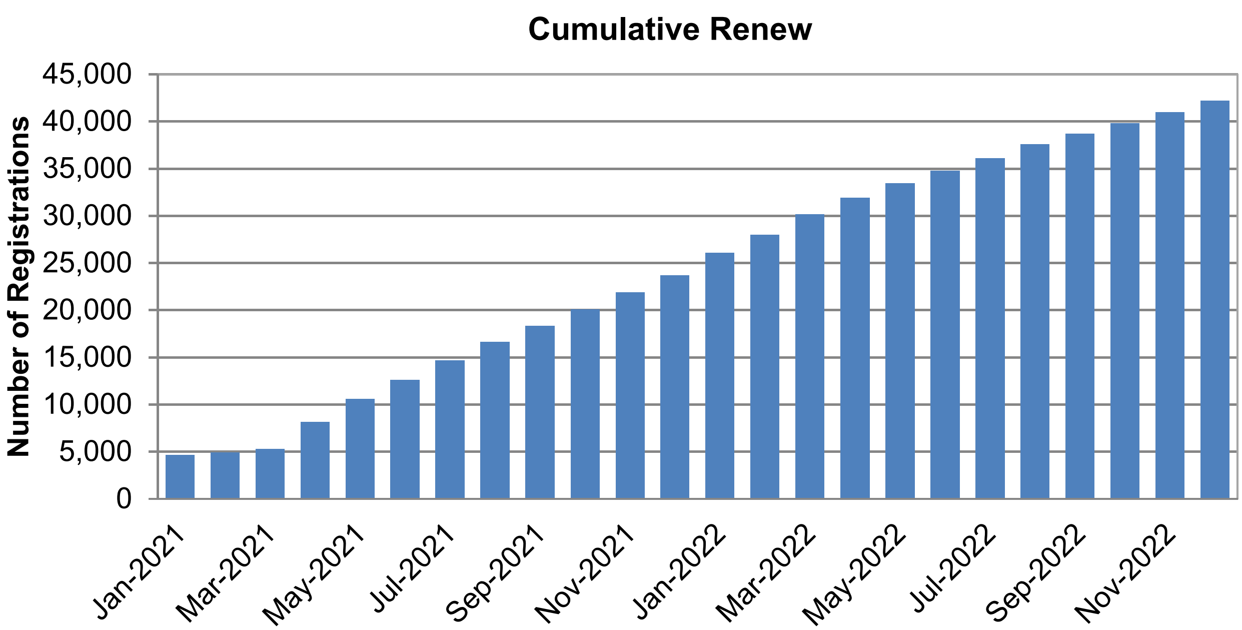


An average of 305,000 expirations per month was reported on a cumulative basis between January–December 2022 as shown below. (This equals approximately 7,812 new average expiries for each month during January–December 2022):

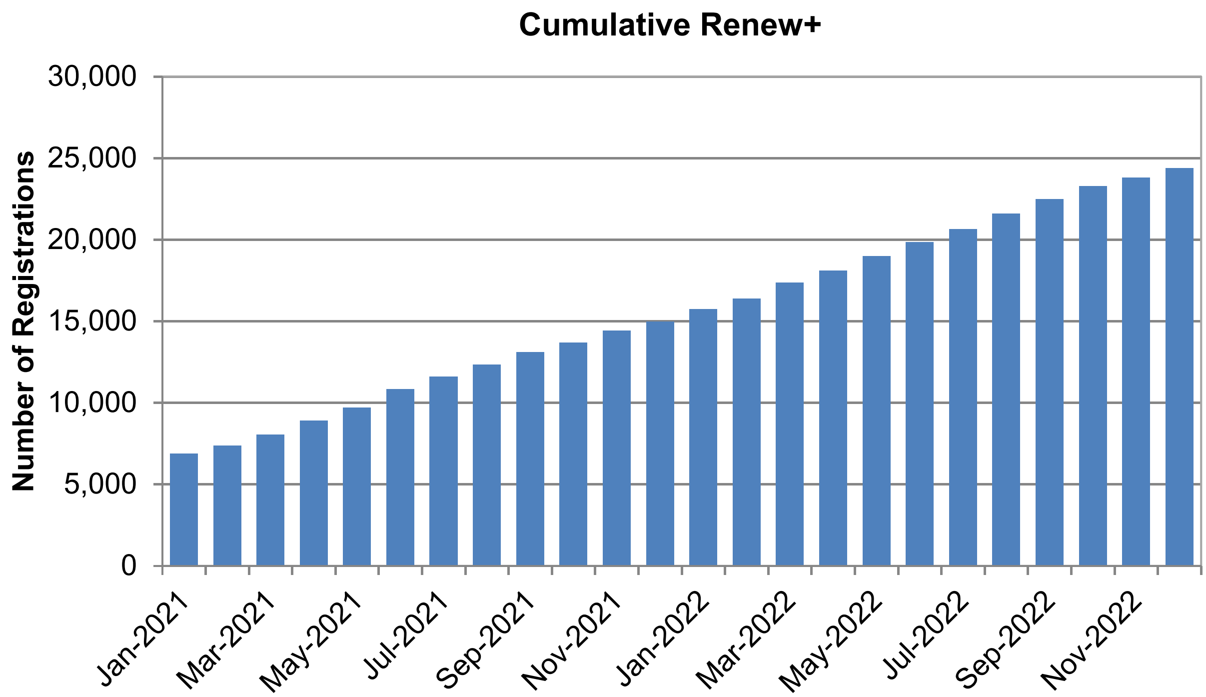
[32] See https://faadronezone.faa.gov/#/.



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



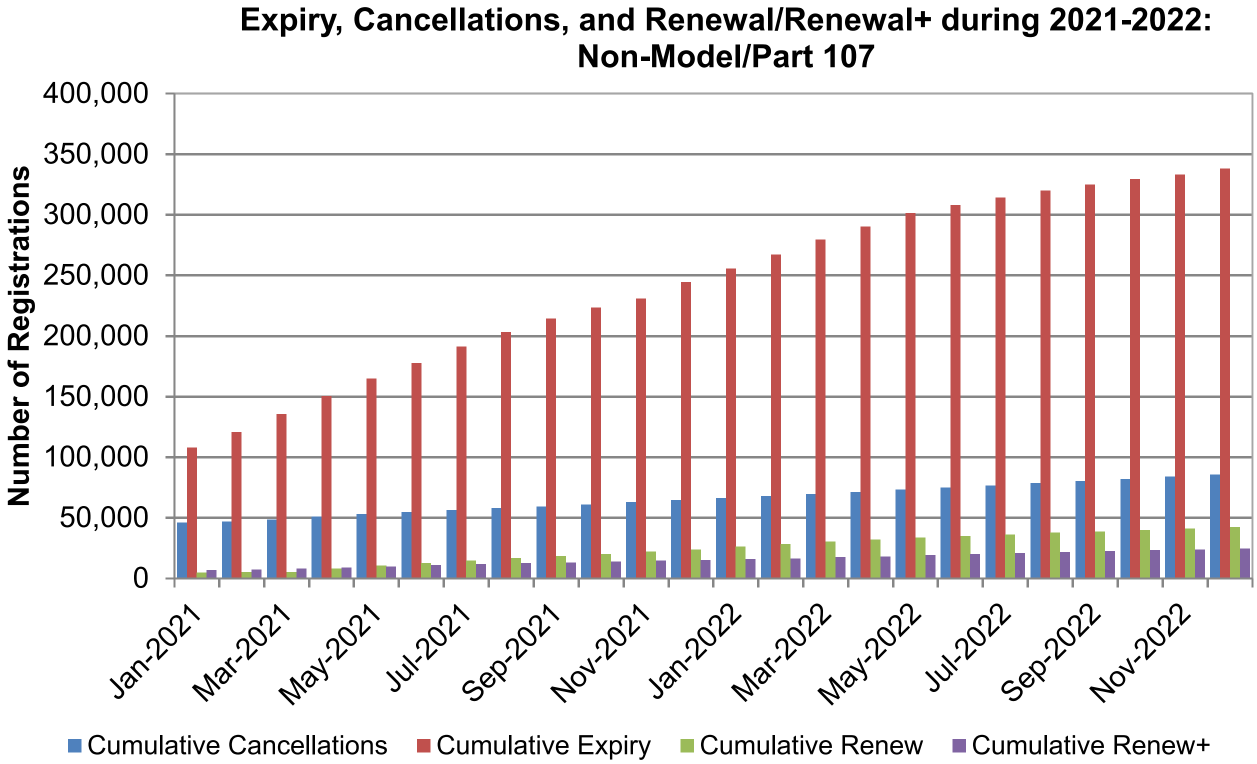
Similar to renewals, “Renew+” (i.e., re-registrations after expiry), logged at a rate much higher than last year to an average 20,216/month on a cumulative basis. This is an average of 784 new Renew+ each month during January–December 2022, as reported below:



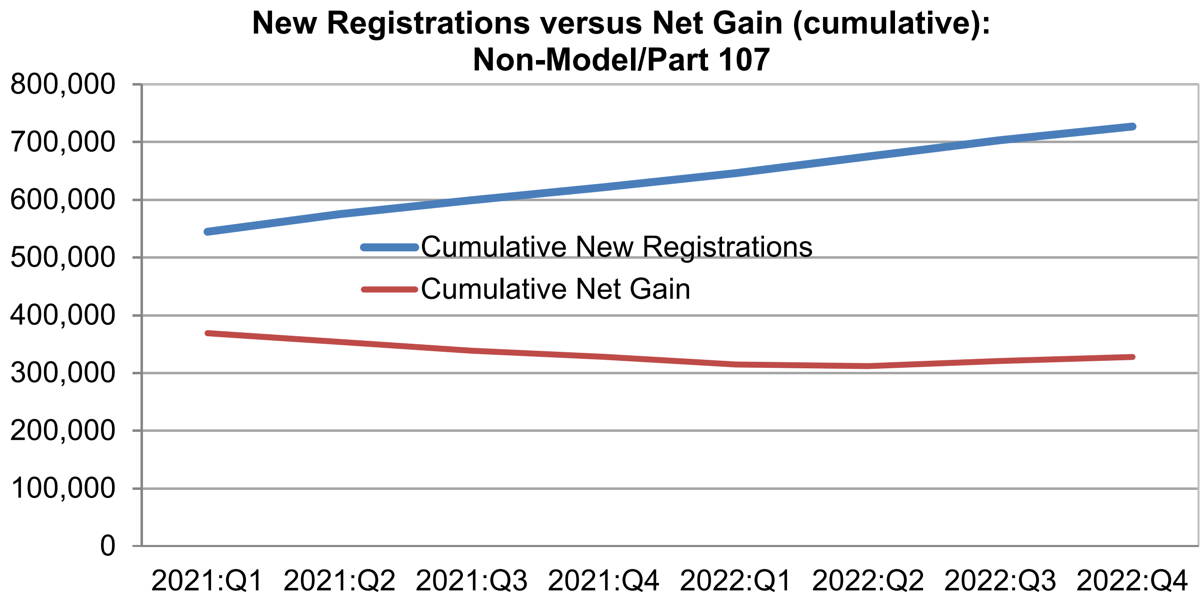
As in the case of recreational/model registrations, calculating active/effective registrations for a particular day requires calculating the "net gain/loss" of registrations for each preceding day and adding them with the particular day (i.e. calculating the running sum).

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

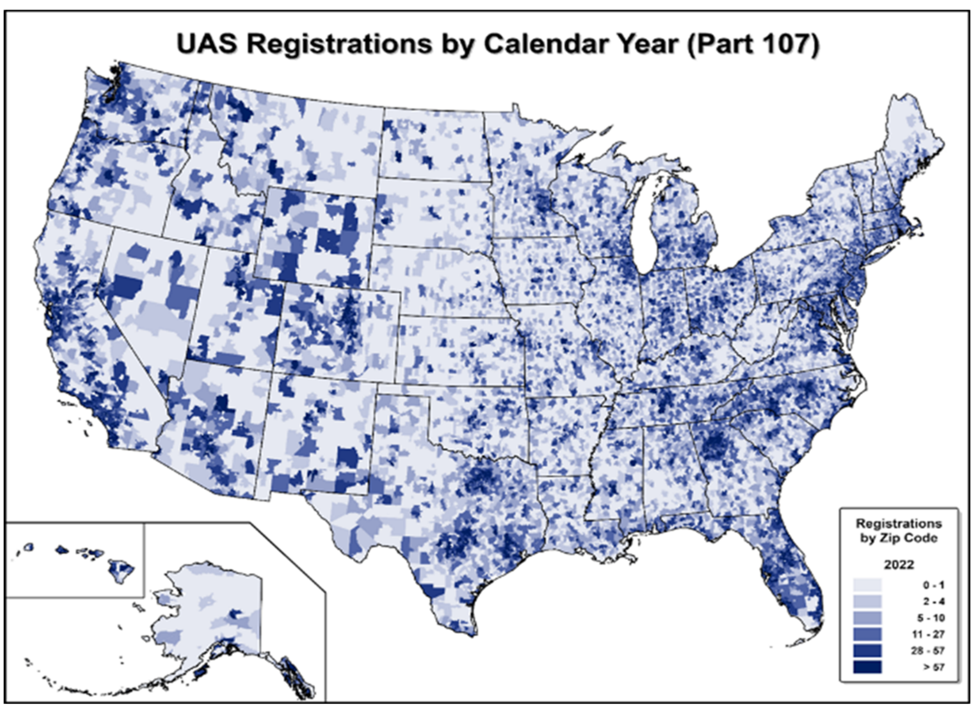
A summary of the above 4 charts is provided in below to relate the relative contributions of cancellations, expiry, renew and renew+:



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



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



.

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

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

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

*: Effective/Active fleet counts;

**: New registration counts based on fleet counts;

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

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

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

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

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

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

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

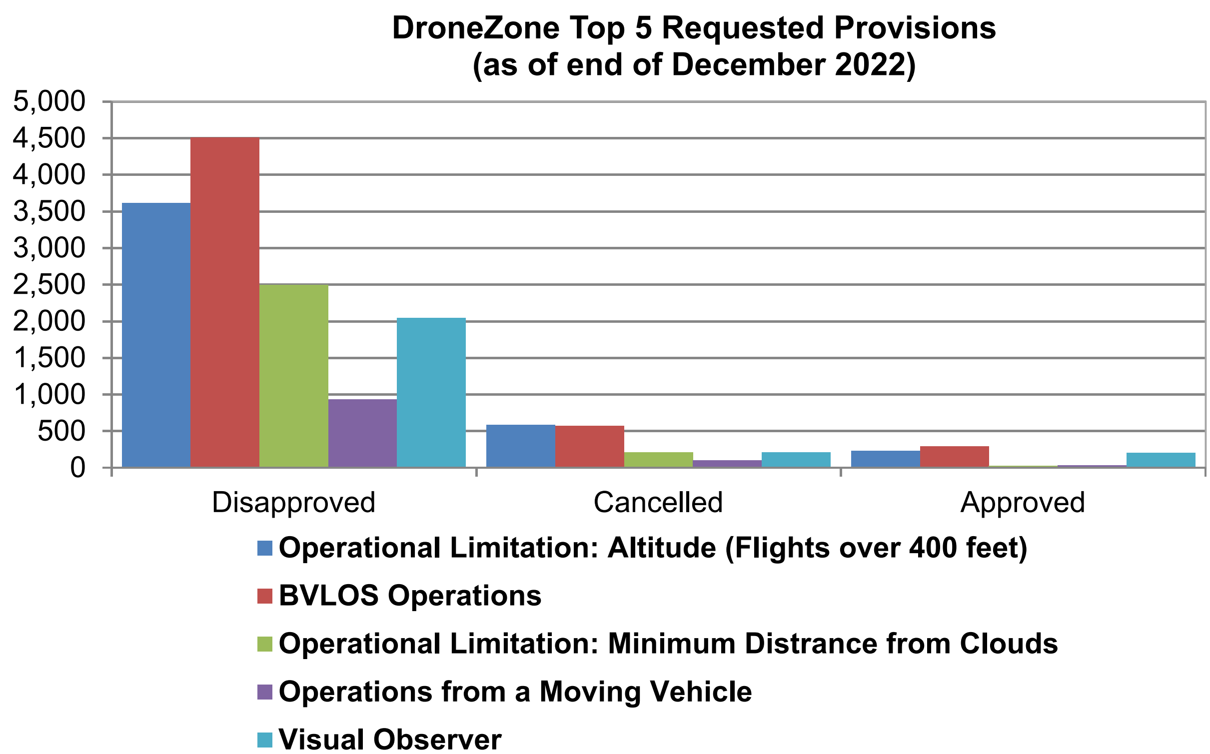
[35] This is driven by the combined effects of projected underlying growth rates of cancellations, expiry, new registrations, and renewals.

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

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

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

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



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

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

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

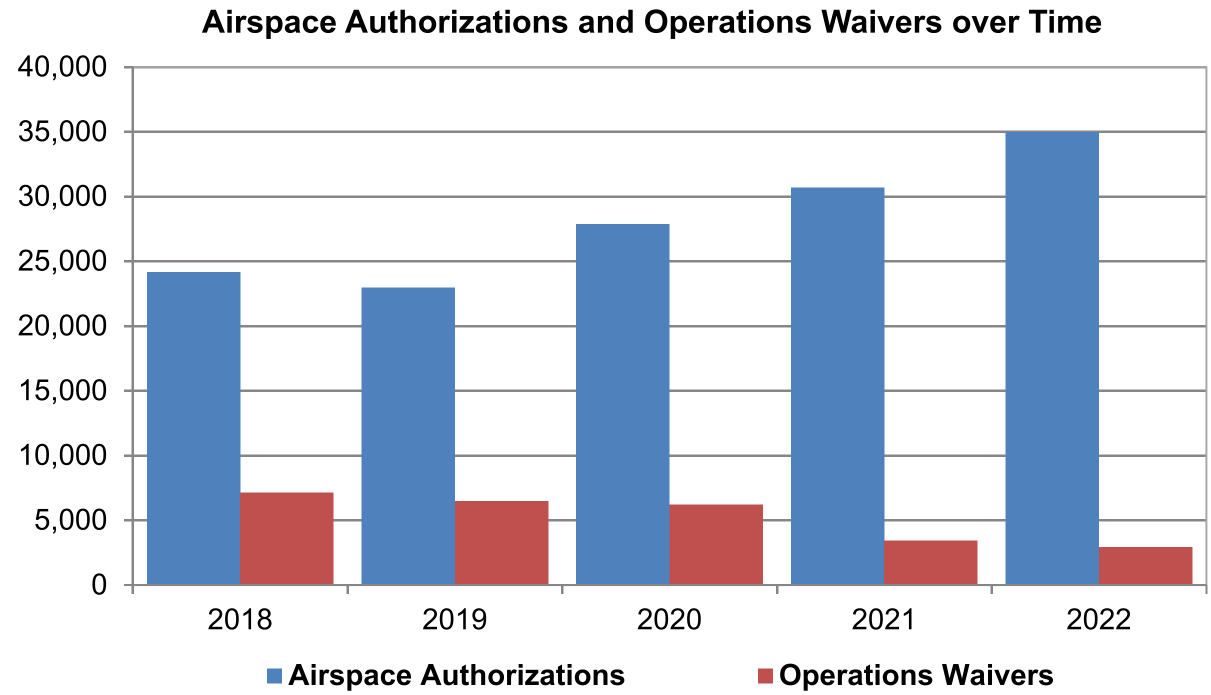
Airspace authorizations have been growing over time as shown in the chart below. While airspace authorizations have been growing consistently since 2019, at an average annual rate exceeding 10%, operations waivers have been declining over the years. Nearly 60% of airspace authorizations and waiver requests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

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

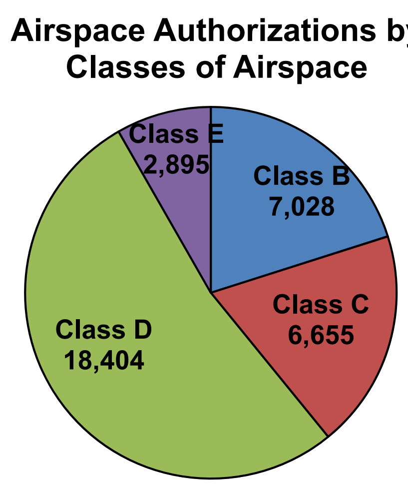
[42] See § 107.29. An operation at night was defined as an operation conducted between the end of evening civil twilight and the beginning of morning civil twilight, as published in the Air Almanac, converted to local time (ibid).

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

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



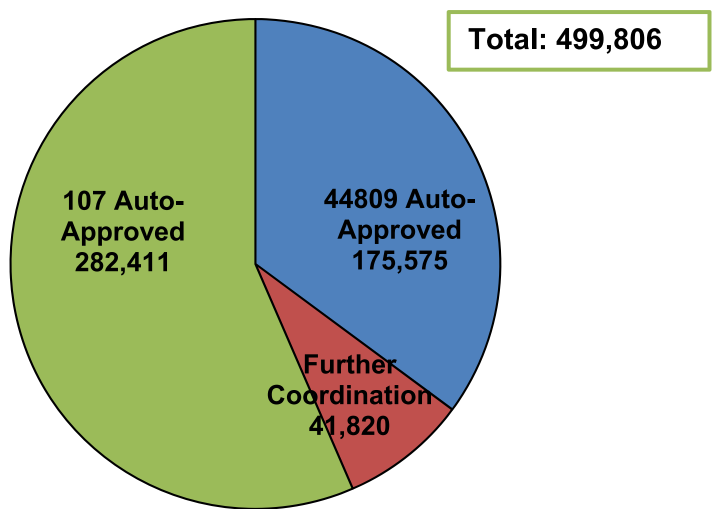
While over half continue to be for Class D airspace (i.e., smaller airports with control towers), other classes were also requested, granted and regularly flown as reported in the chart below:



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

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

LAANC Authorization Types



2022 Survey and Preliminary Results

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

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

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

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

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

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

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

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

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

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

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

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

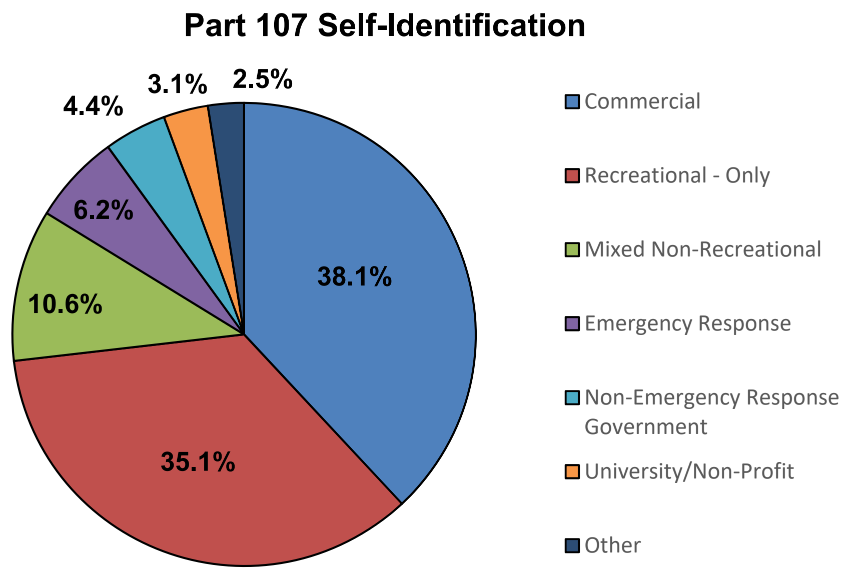
One of the questions was a self-report on the type of sUAS operator the respondent considered themselves. Respondents were given the multiple-selection options of business, emergency response, non-emergency government, university/non-profit, and recreational as well as a fill-in "other" category. For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

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

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

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

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



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

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

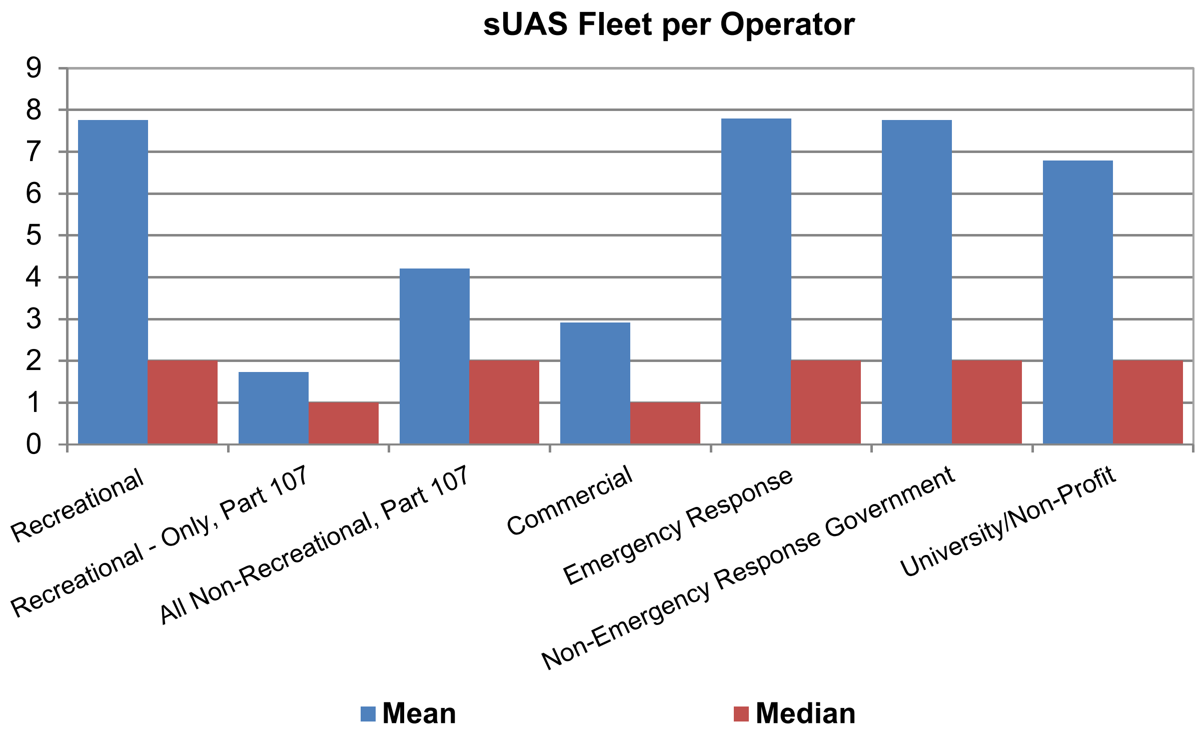
The average duration of each flight for recreational registrants is 24.7 minutes, but the median duration is only 12 minutes.57 In closer consideration of these responses, we find that 0.9% of respondents reported more than 60 minutes for the duration of each flight, which is generally the flight time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

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

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

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

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



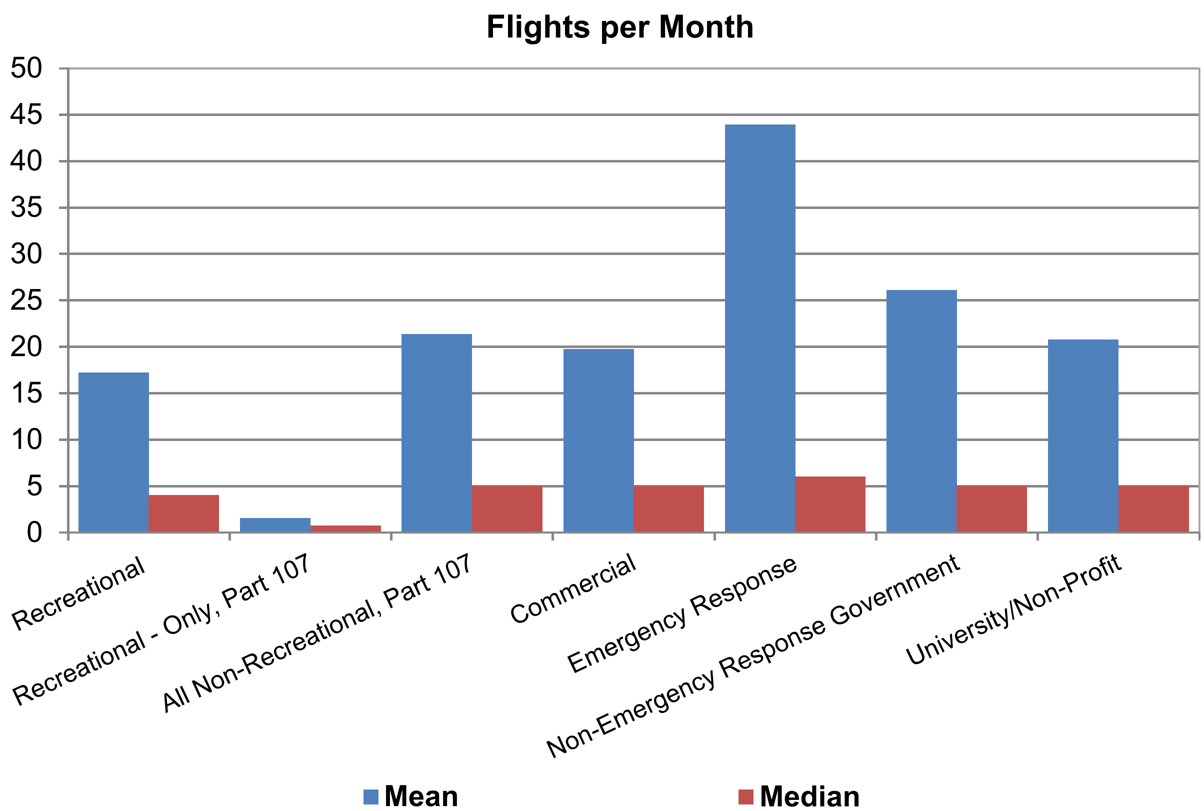
Part 107 operators engaged in non-recreational activities flew 21 flights on average per month with a median of 5 flights.58 However, the number of flights changed based on how the respondent self-identified. Respondents who identified as commercial operators flew slightly fewer times per month compared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

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

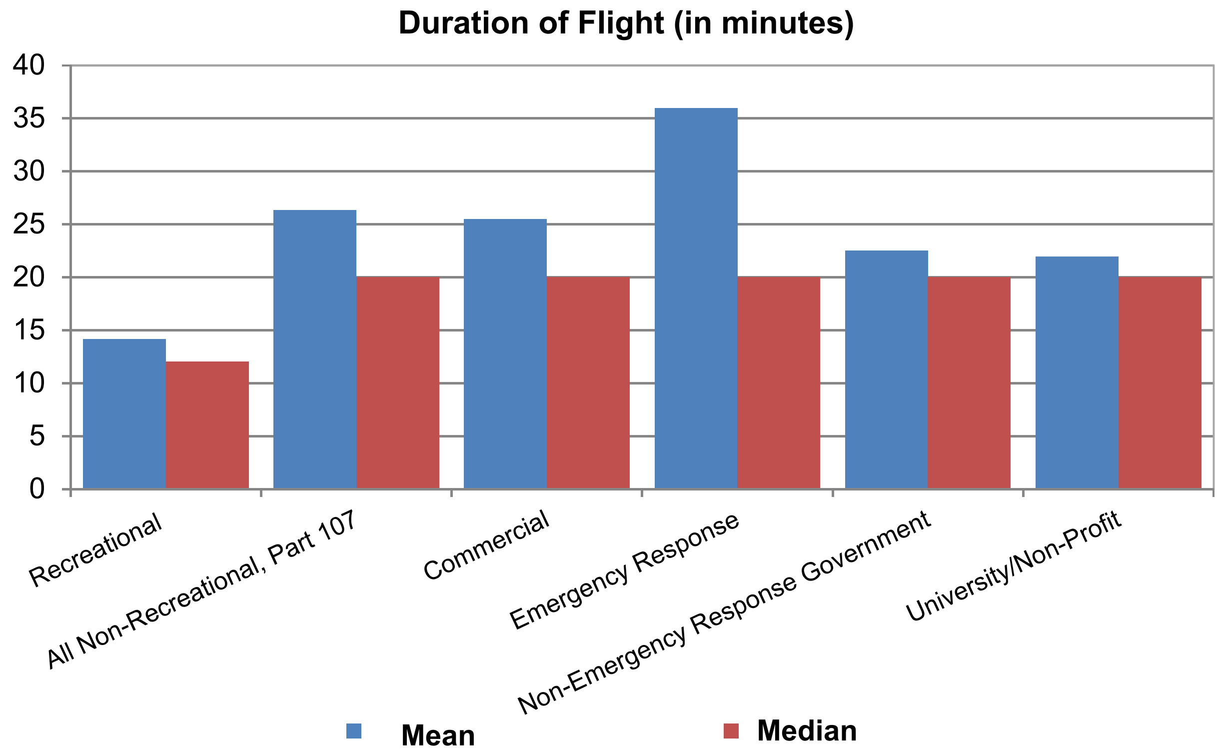
In general, non-recreational operators spent a total of 8.4 hours per month operating their sUAS for non-recreational purposes. However, the median was far less at just an hour and a half. Operators who identified as commercial operators flew 7.1 hours per month

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

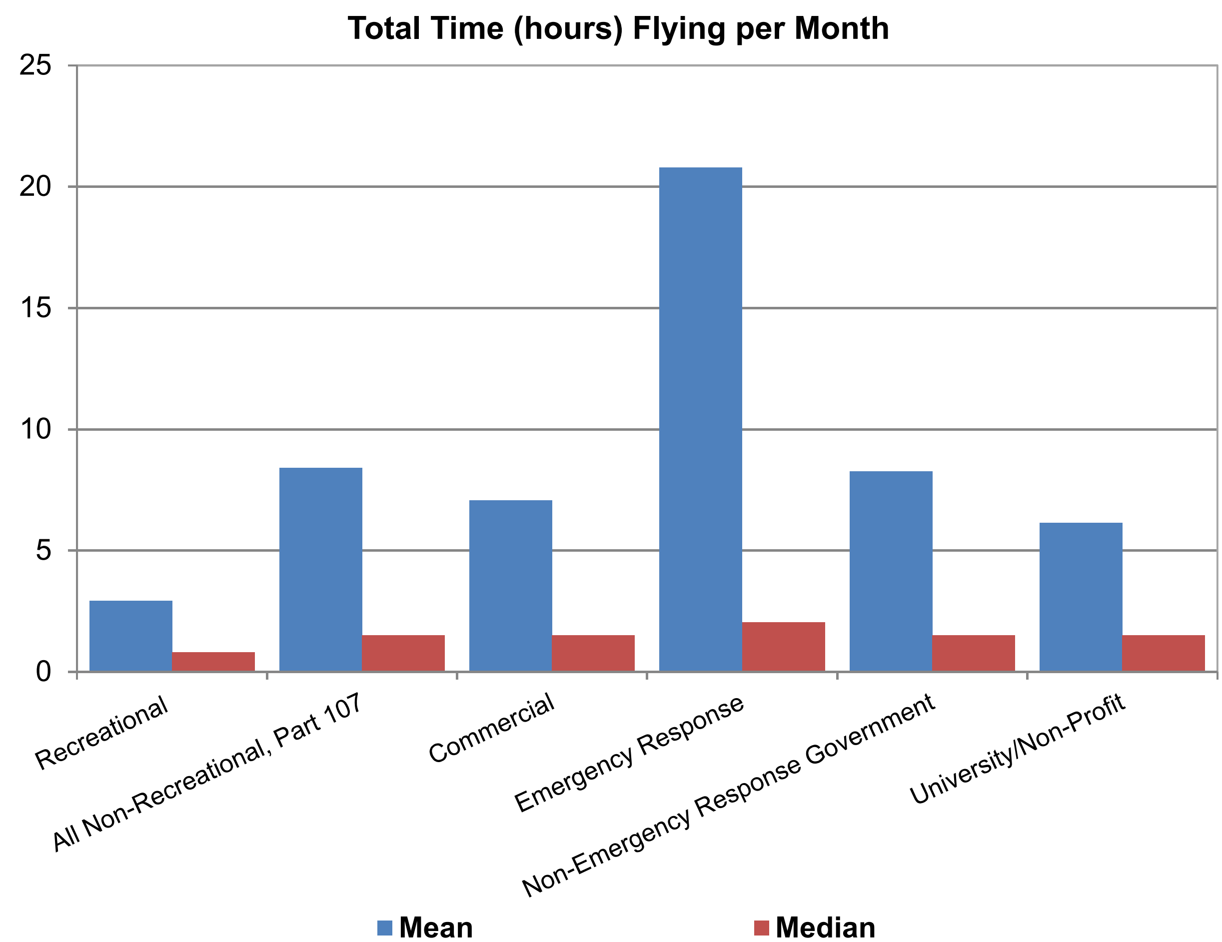
on average, less than the general population of non-recreational operators but shared the same median. Emergency-response and non-emergency government have a greater averages total operating time compared to the general population of non-recreational operators with an average of 20.8 and 8.3 hours, respectively,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



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



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



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

Remote Pilot Forecast

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

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

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

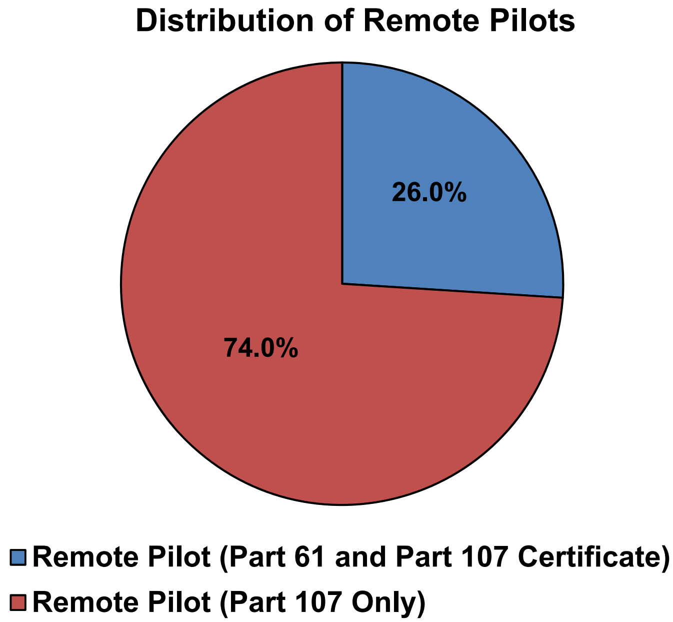
Following the process above, the FAA classifies RPs into two categories:

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

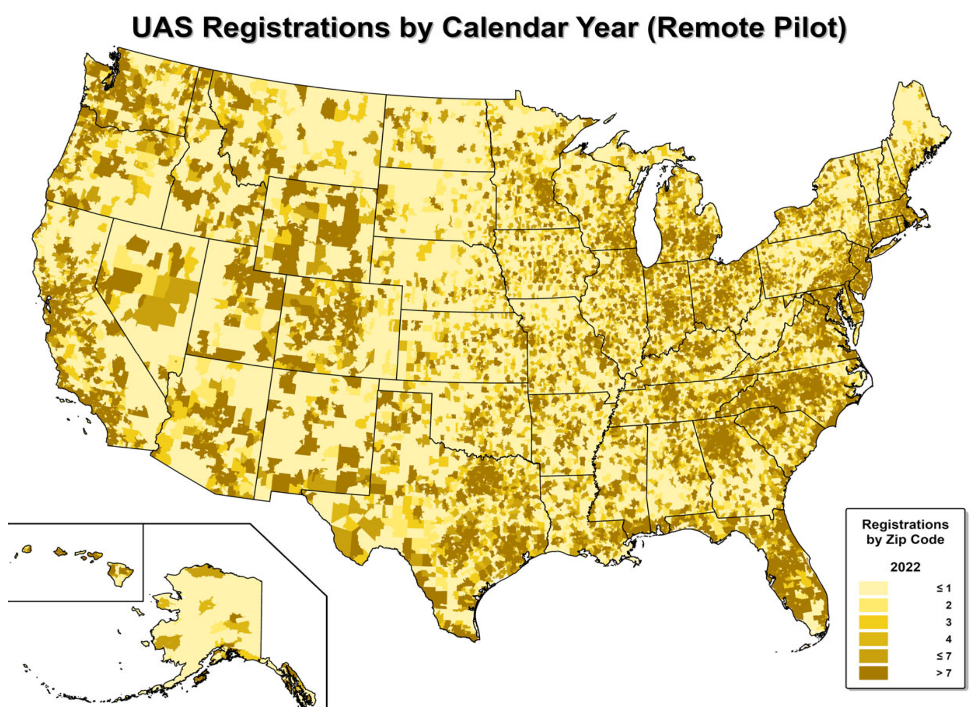
The chart below provides a distribution of these two types of RPs who presently have certificates.

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

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

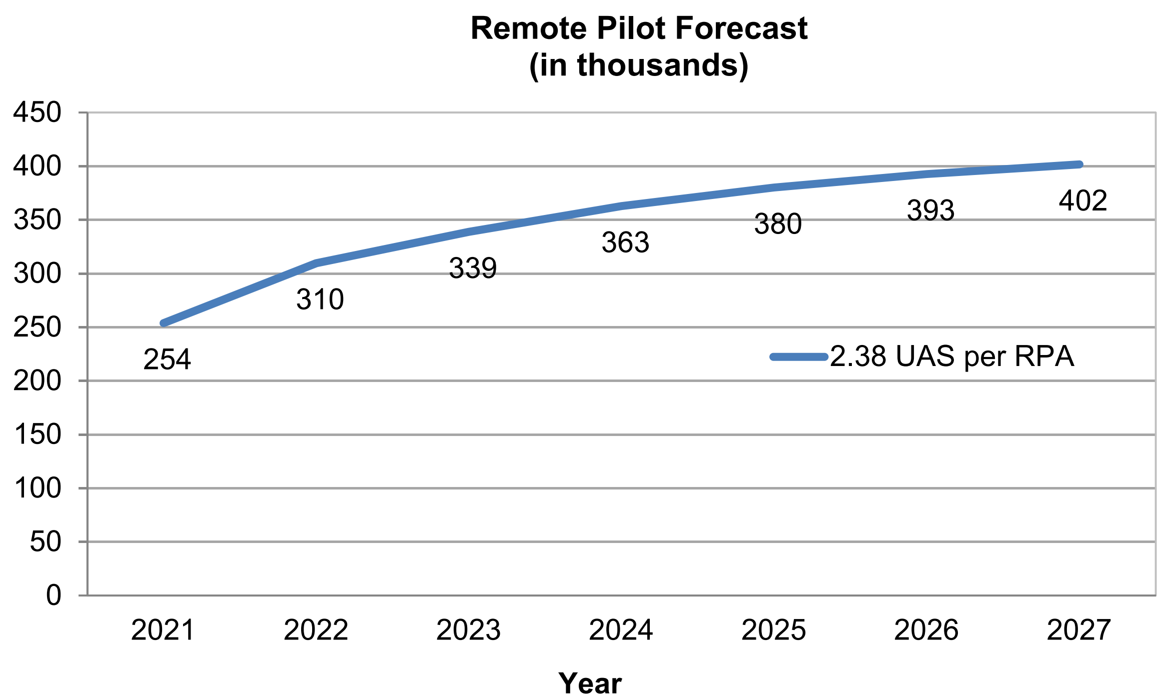


Around 74% of the RPs are Part 107 RPs only. Over 90% of those who took the exam passed and obtained RP certification. A cumulative density distribution of remote pilots by zip codes in 2021 is provided in the map below.



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

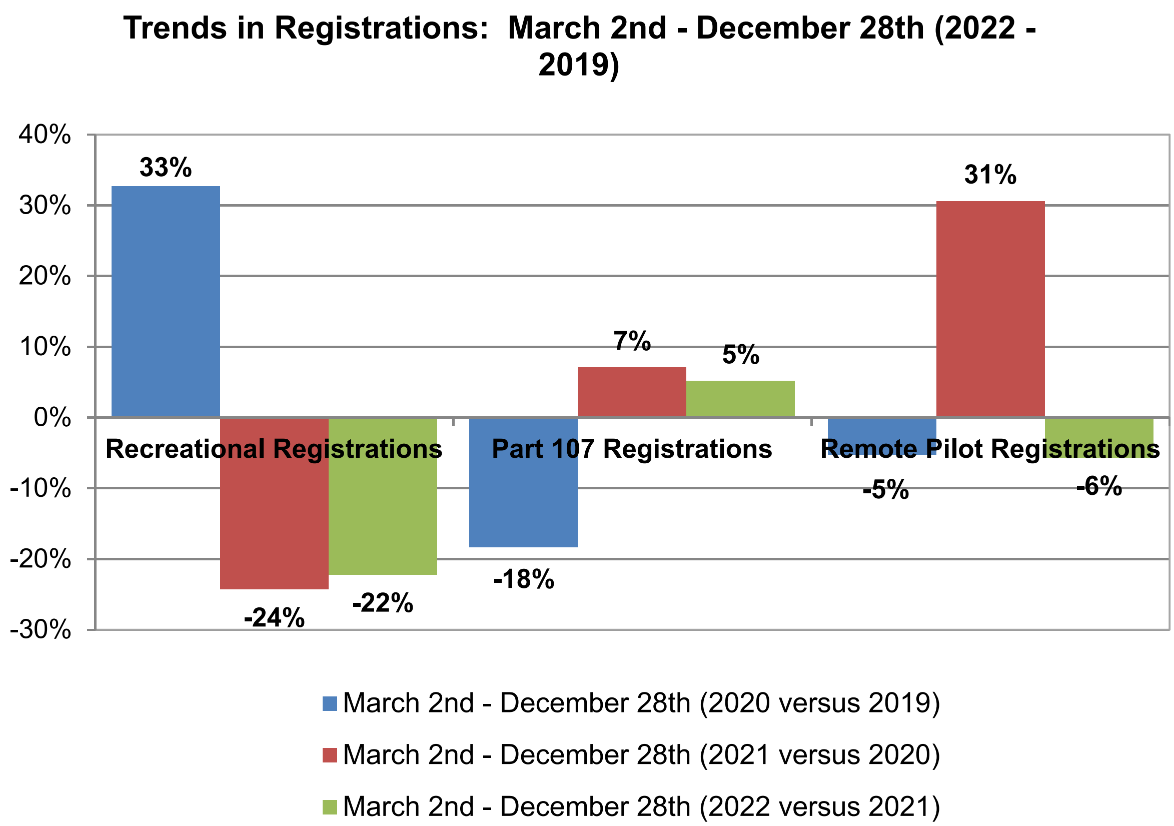
Using these assumptions and combined with the base scenario of the commercial/Part 107 small drone forecast, we project RPs in the graph below. Last year, the FAA projected RPs to be approximately 294,276 by the end of 2022. Actual registrations by the end of 2022 totaled 309,713 (or more than 15,437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



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

COVID-19 and Its Impact on sUAS

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



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

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

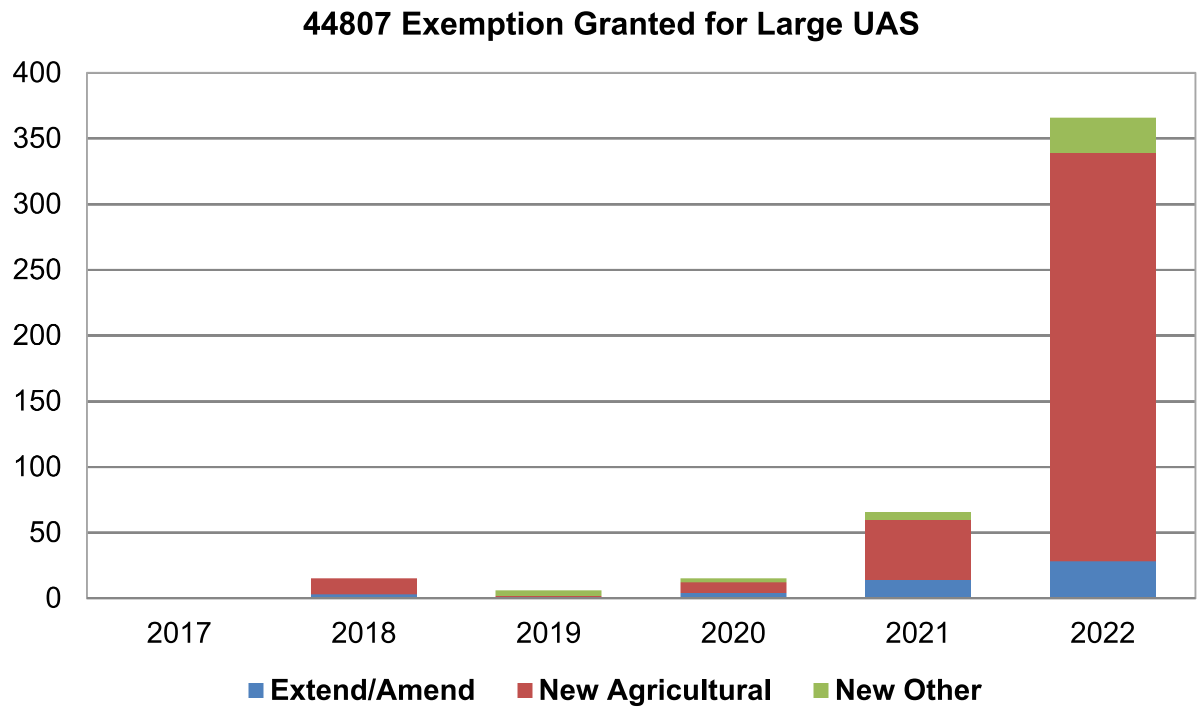
Large UAS

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

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

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

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

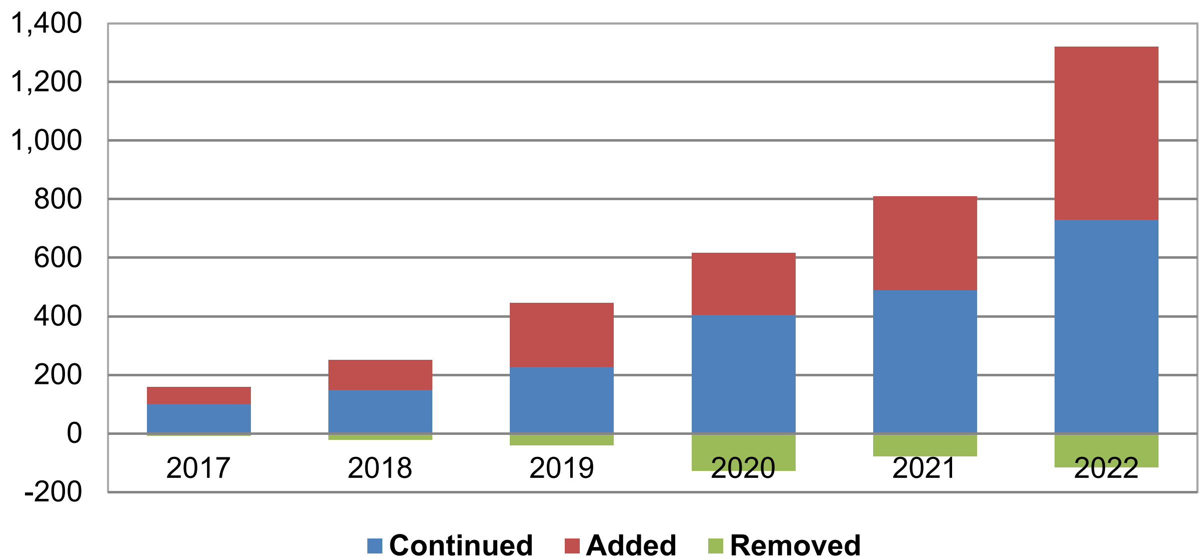


The rapid increase in exemptions granted suggests that the safety cases for specific operation have been sufficiently demonstrated to regulators such that the granting exemptions for these narrow operations is now routine. In addition, the small number of firms representing operators suggests specialization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

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

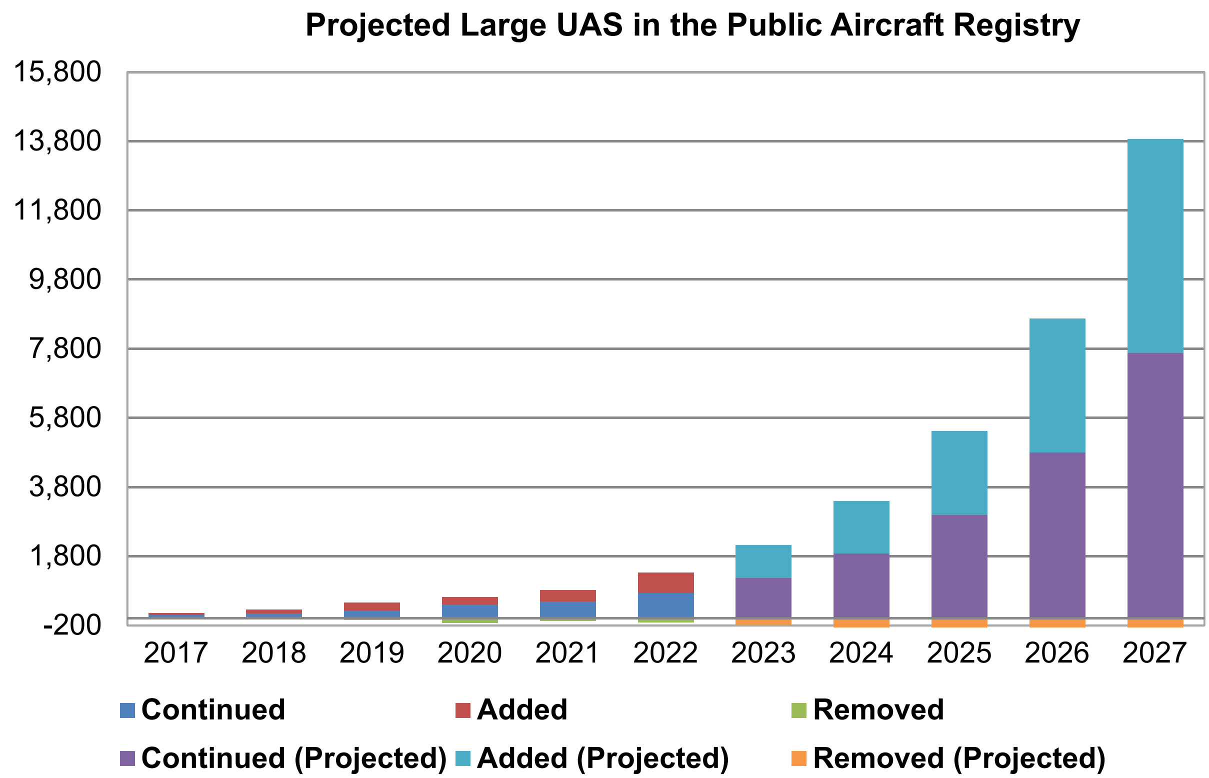
With robust demand for lUAS operation indicated by 44807 exemptions, we expect the growth of new lUAS over the next 5 years to keep pace with the growth observed in 2022. As such, we expect 6,189 new lUAS will be added to the PAR in 2027, with a total active lUAS fleet of 12,651 aircraft by the end of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

Large UAS in the Public Aircraft Registry



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

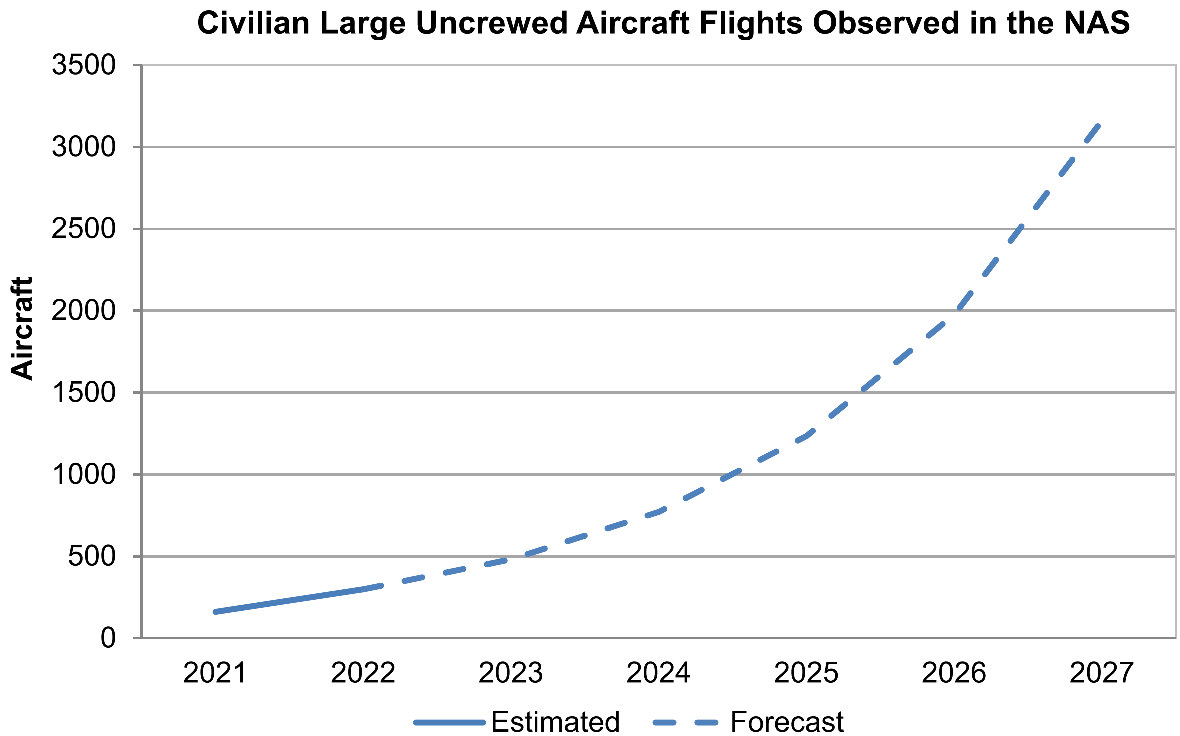
[65] The Federal Funds Effective Rate has risen from 0.8% at the beginning of 2022 to 4.57% at the beginning of 2023 and Moody’s Aaa bond yields have increased from 2.93% at the beginning of 2022 to 4.40% at the beginning of 2023. Both suggest higher costs of borrowing for capital purchases.



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

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

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



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

UAS Imports: Preliminary Analysis of Data

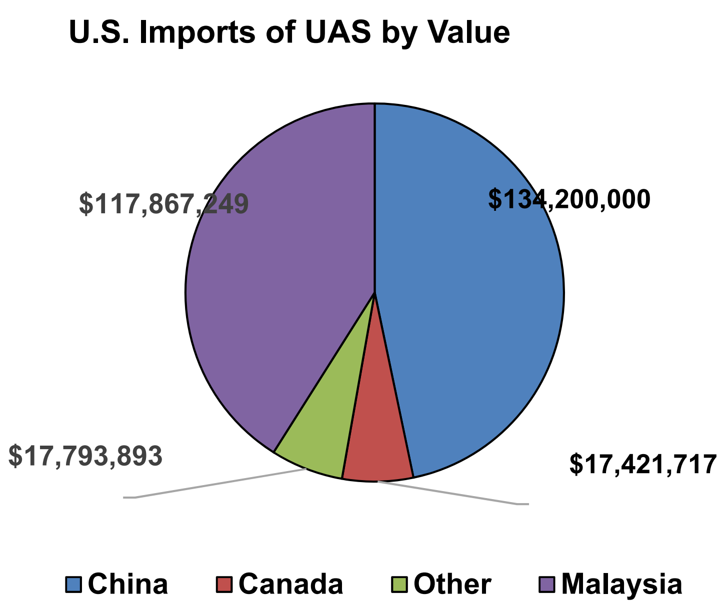
On January 27th 2022, the White House issued a proclamation to update the Harmonized Trade Schedule of the United States (HTSUS) to match recommendations by the World Customs Organization.[69] As part of the update, UAS received their own categories, separating UAS from crewed aircraft or toys.

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

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

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

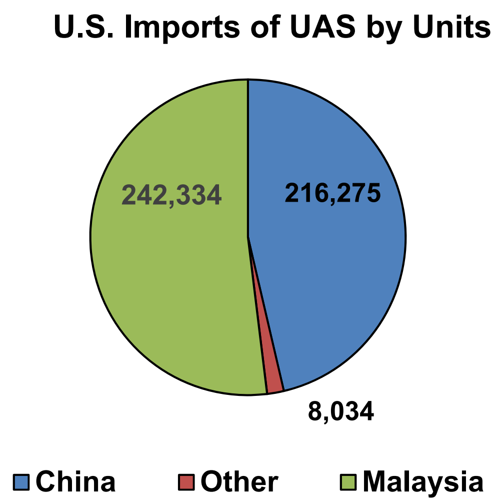
Code	Type	Weight
8806	Rc Unmanned Aircraft	
8806.10	Rc Unmanned Aircraft Carriage of Passengers	Unspecified
8806.21	Rc Unmanned Aircraft	Not Over 250 g
8806.22	Rc Unmanned Aircraft	250 g - 7 kg
8806.23	Rc Unmanned Aircraft	7 kg - 25 kg
8806.24	Rc Unmanned Aircraft	25 kg - 150 kg
8806.29	Rc Unmanned Aircraft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

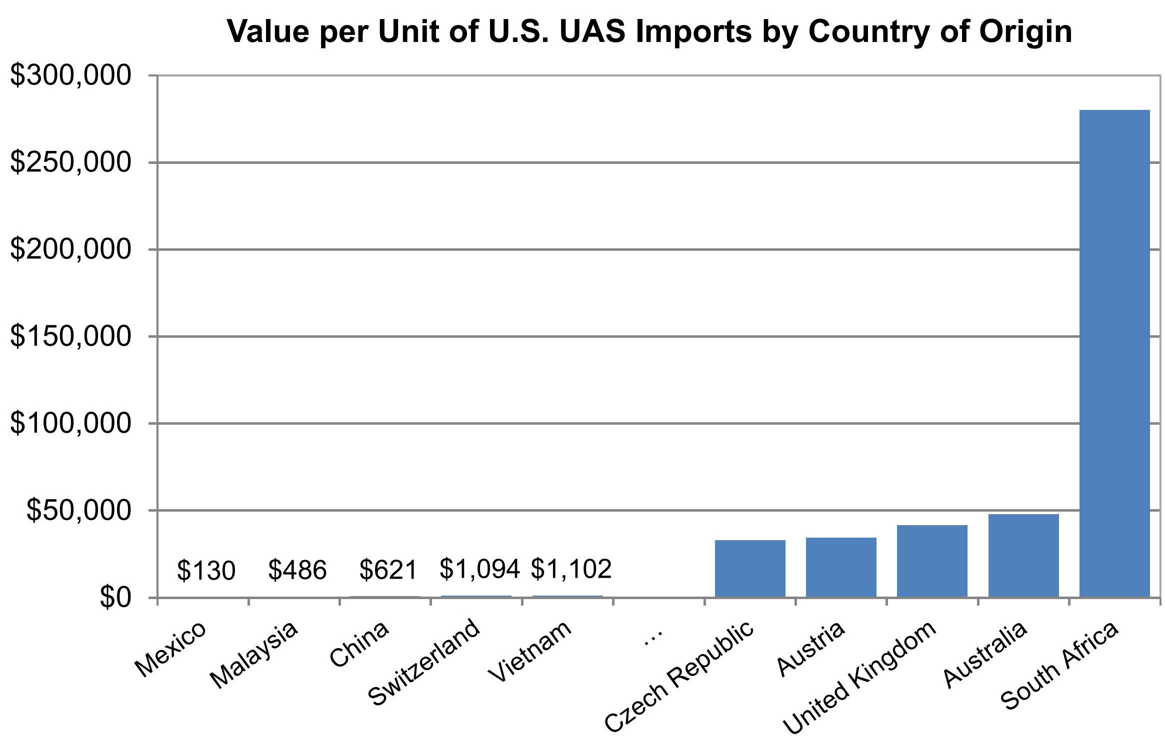


In 2022, the United States imported more than 466,000 UAS worth $287 million. The vast majority of UAS imports, both in terms of value and units, are from either China or

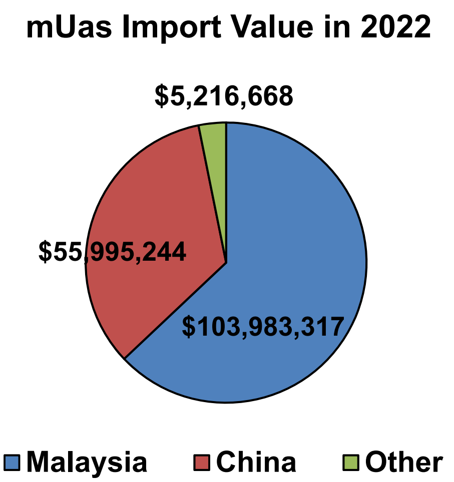
[70] The categories also included “Not Elsewhere Specified or Included (NESOI)” and “duplicate category” for each of the sub-category codes.

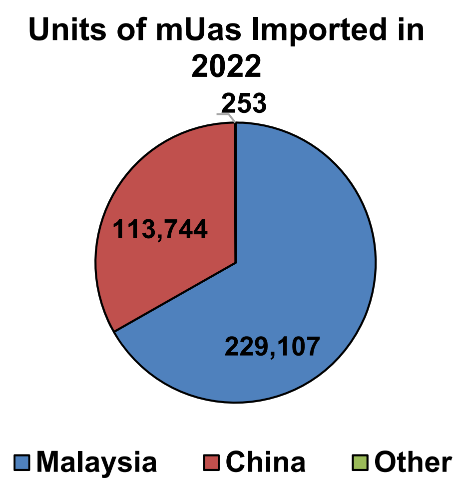
Malaysia with Canada being a notable exporter of UAS in terms of values. On average, both China and Malaysia are exporting low value UAS occupying bottom 5 in terms of value per unit imported into the United States, along with Mexico, Switzerland, and Vietnam. Conversely, South Africa, Australia, the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



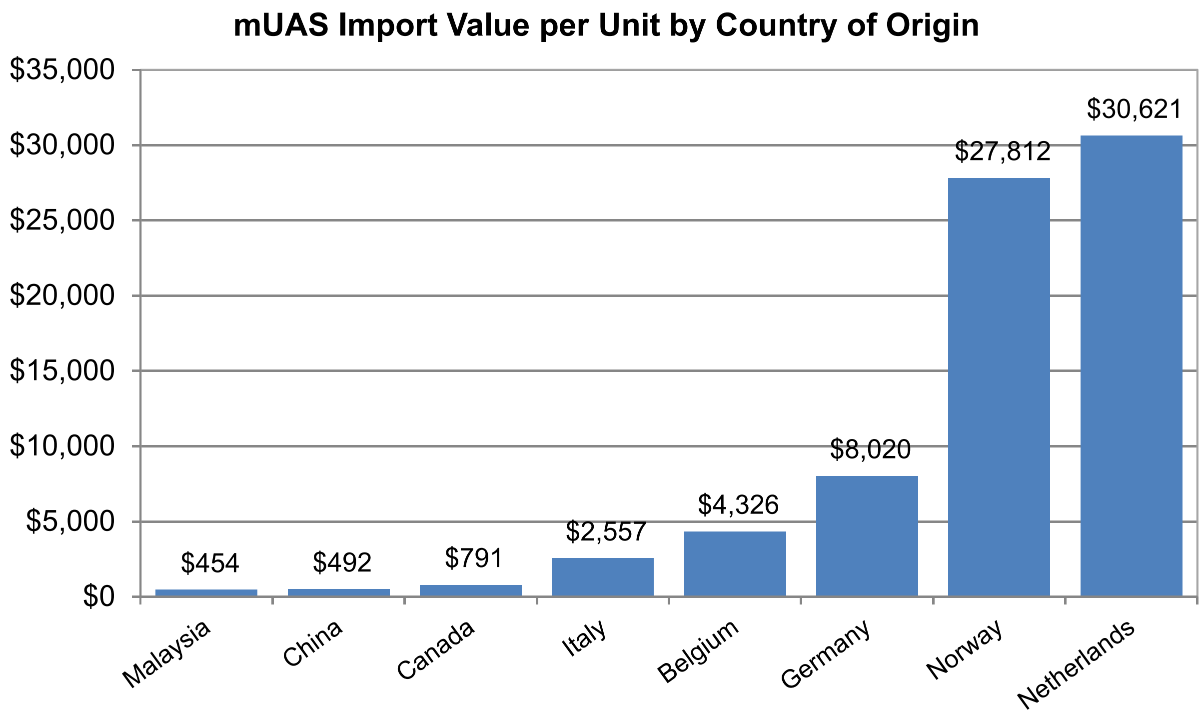


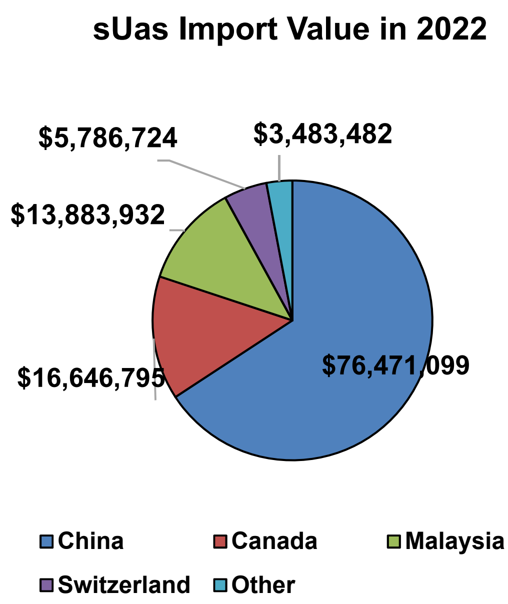
Using the codes for UAS, the imported UAS can be segmented based on weight. Part 107 and Section 44809 do not require operator with UAS weighing less than 0.55lbs (or 250g) to register under Part 107 or Section 44809 and both Part 107 and section 44809 forbid the operation of UAS greater than 55lbs (or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

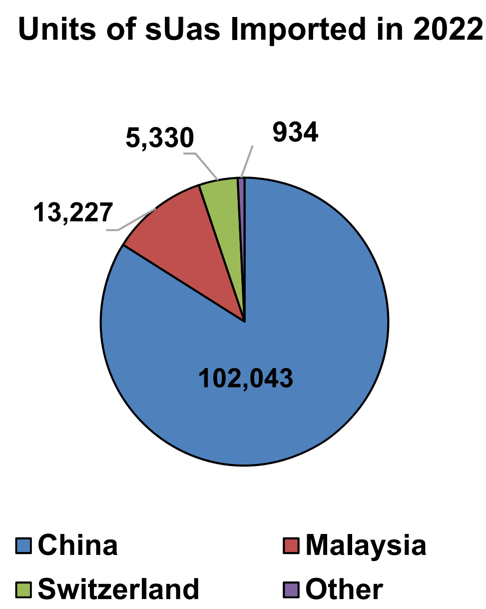


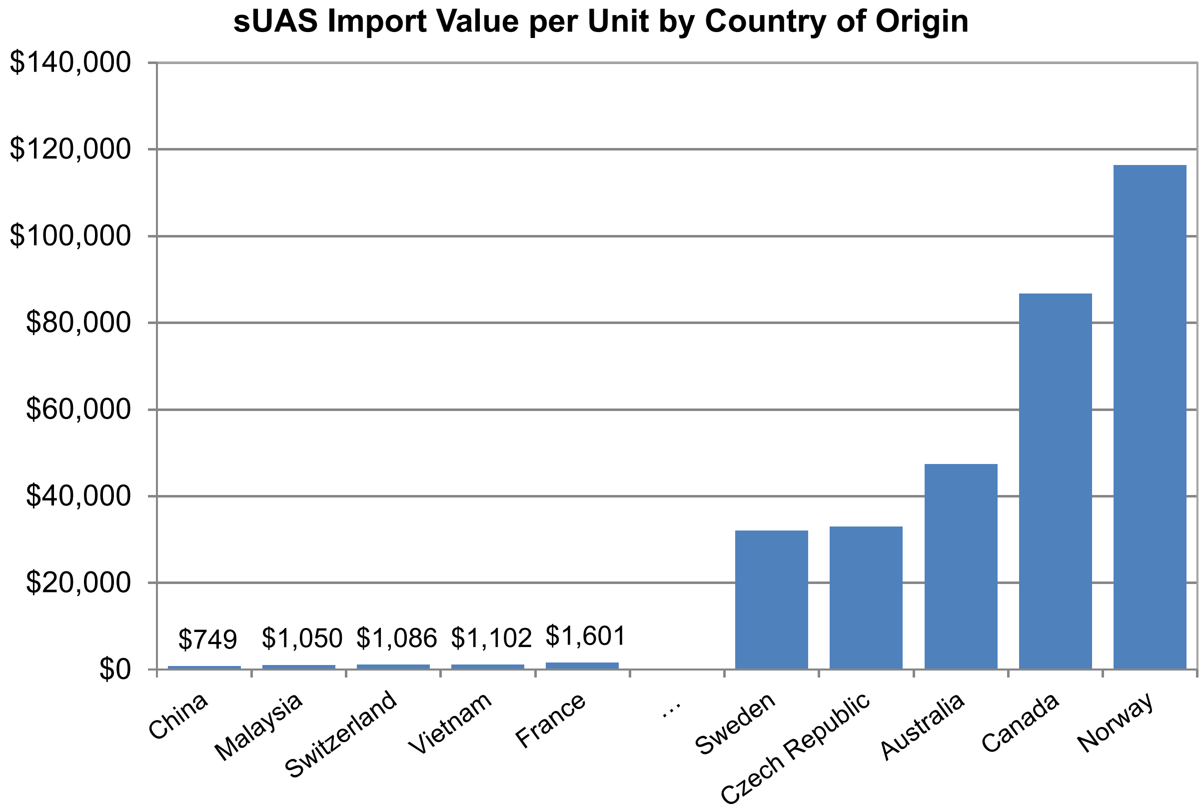


A total of 343,104 mUAS were imported into the United States in 2022 with a value of over $165 million. China and Malaysia dominated this segment of the UAS market, exporting 113,744 and 229,107 units worth $56 million and $104 million, respectively. Between the two countries, their exports to the United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

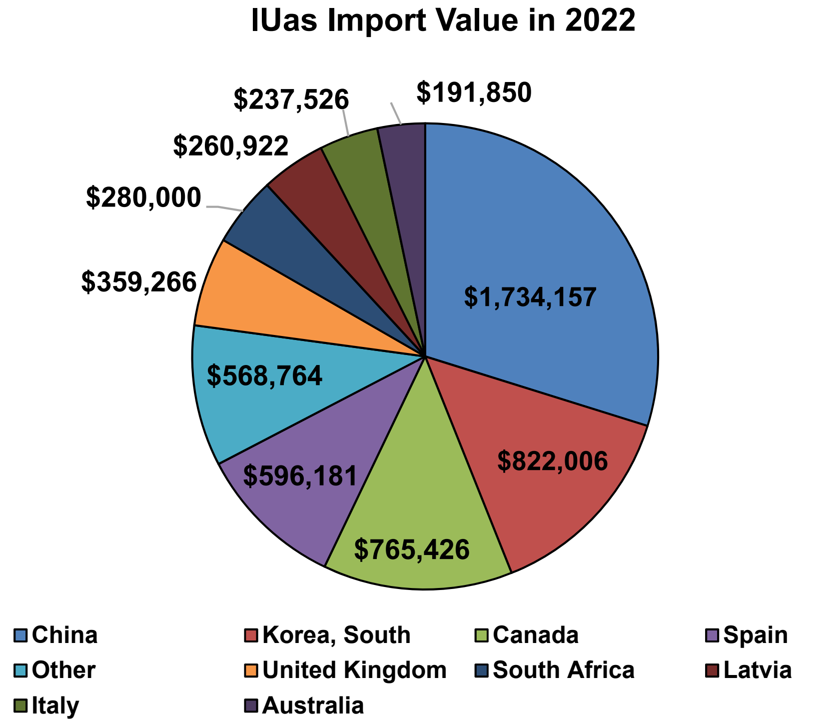

mUAS Import Value per Unit by Country of Origin
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
$454
$492
$791
$2,557
$4,326
$8,020
$27,812
$30,621
Malaysia
China
Canada
Italy
Belgium
Germany
Norway
Netherlands

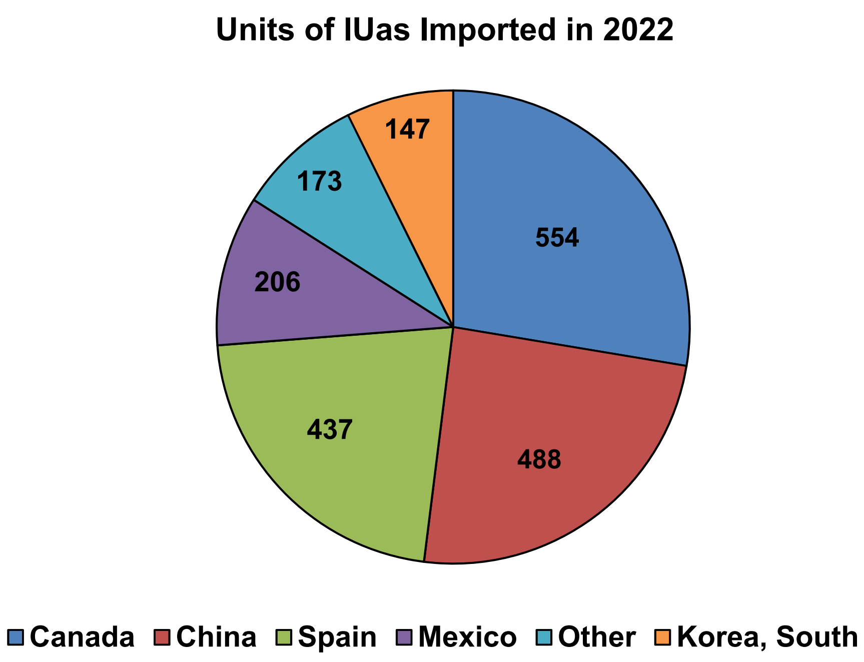

sUas Import Value in 2022
$5,786,724
$3,483,482
$13,883,932
$16,646,795
$76,471,099
China
Canada
Malaysia
Switzerland
Other

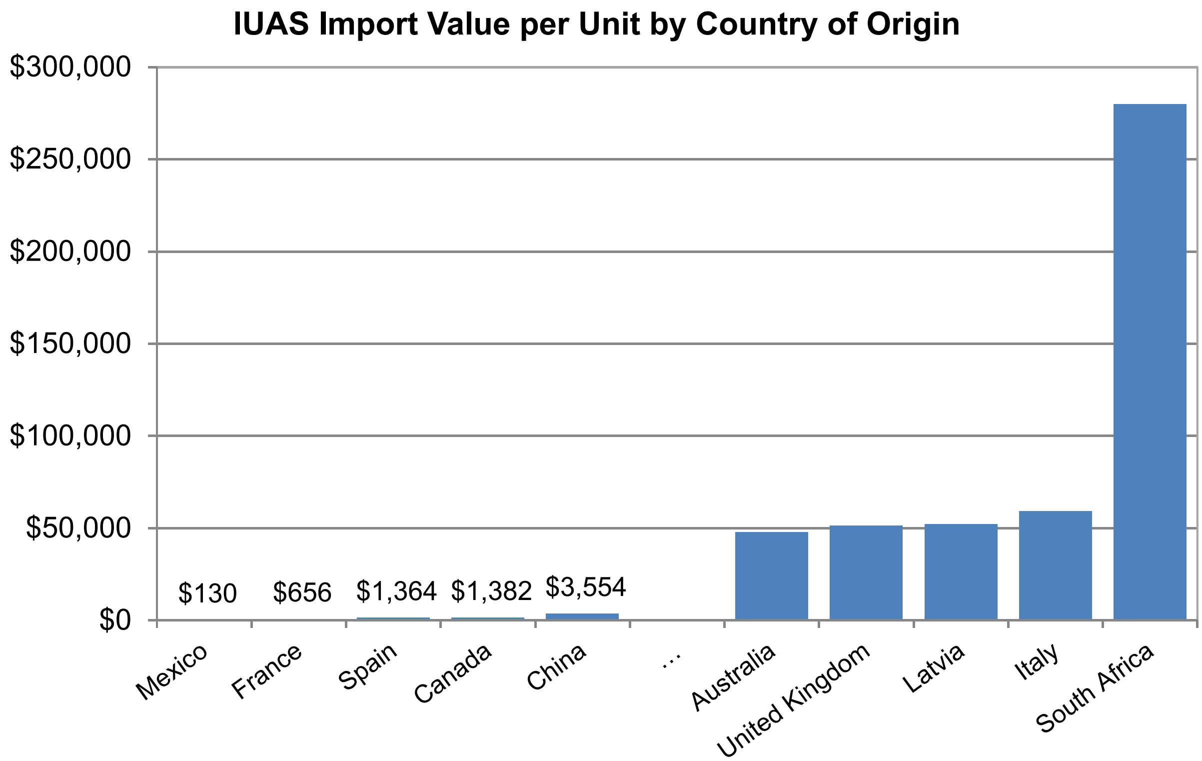

Units of sUas Imported in 2022
5,330
934
13,227
102,043
China
Malaysia
Switzerland
Other



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


IUas Import Value in 2022
$1,734,157
$822,006
$765,426
$596,181
$568,764
$359,266
$280,000
$260,922
$237,526
$191,850
China
Korea, South
Canada
Spain
Other
United Kingdom
South Africa
Latvia
Italy
Australia


Units of IUas Imported in 2022
554
488
437
206
173
147
Canada
China
Spain
Mexico
Other
Korea, South



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

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

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

Advance Air Mobility

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

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

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

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

---

[71] The community is in the process of establishing nomenclature. Only recently, the community-at-large has moved on to coining earlier-used "urban air mobility" (UAM) as "advanced air mobility" (AAM) to broaden its operational scope, technical characteristics, economic opportunities, and regulatory framework. Under this broad characterization, UAM is considered a subset of AAM.

[72] See https://go.nasa.gov/40Y4hXM.

[73] See https://bit.ly/3U7W2pA.

[74] There appears to be a broad consensus where eVTOLs are expected to be piloted initially (likely during 2025-2030) followed by transition to remotely piloted with increasingly autonomous operations (likely during 2035 and beyond) based on the current state in autonomy research and development, and present status of certification procedures [see Urban Air Mobility: An Airport Perspective (2023), ACRP Research Report #243; available at https://bit.ly/40HQhBu.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

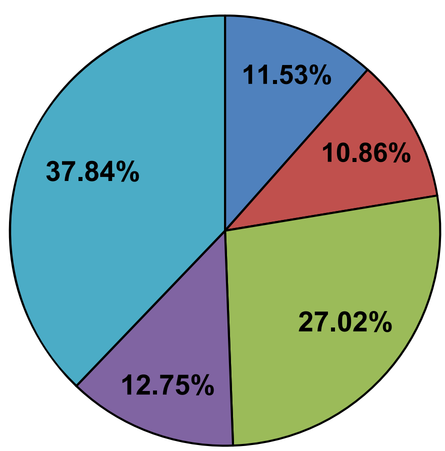
[89] For the version 1.0, see https://go.nasa.gov/3ZJASzr. Version 2.0 of FAA's AAM CONOPS is likely to be published in the spring of 2023.

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

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

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

Categories Served by AAM



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

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

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

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

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

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

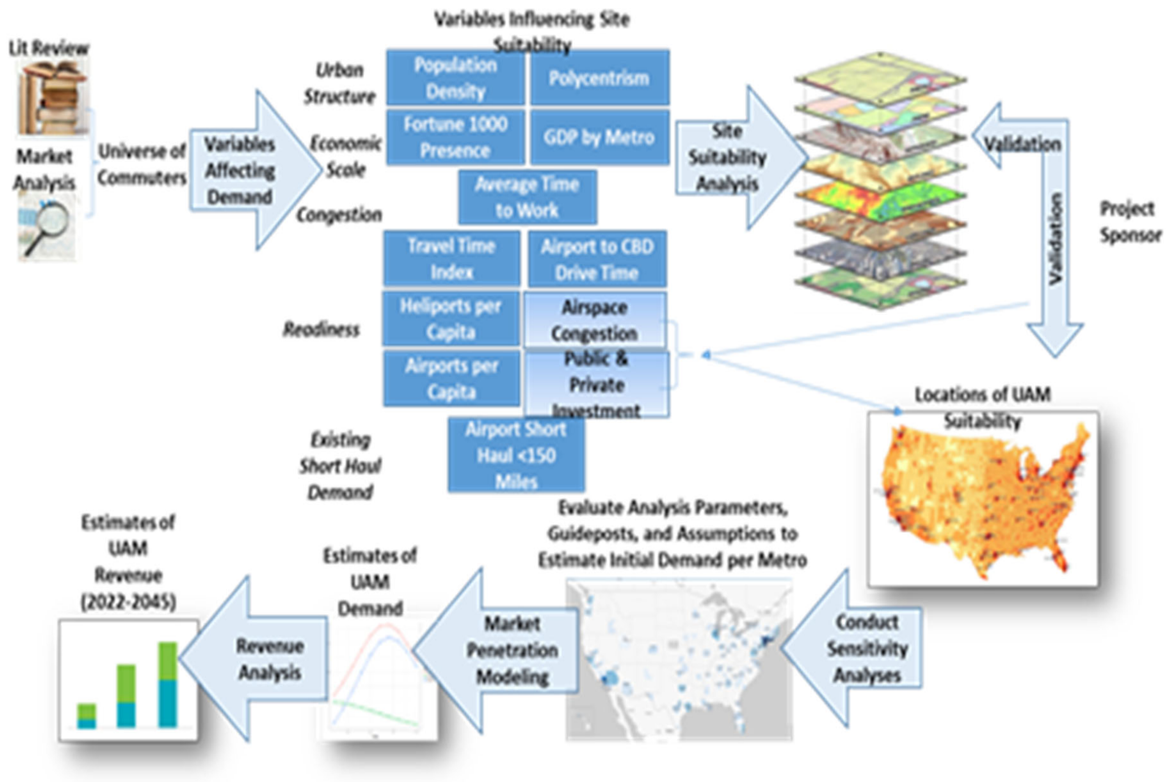
[93] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. [See https://go.nasa.gov/2C5Ten9].

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

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

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

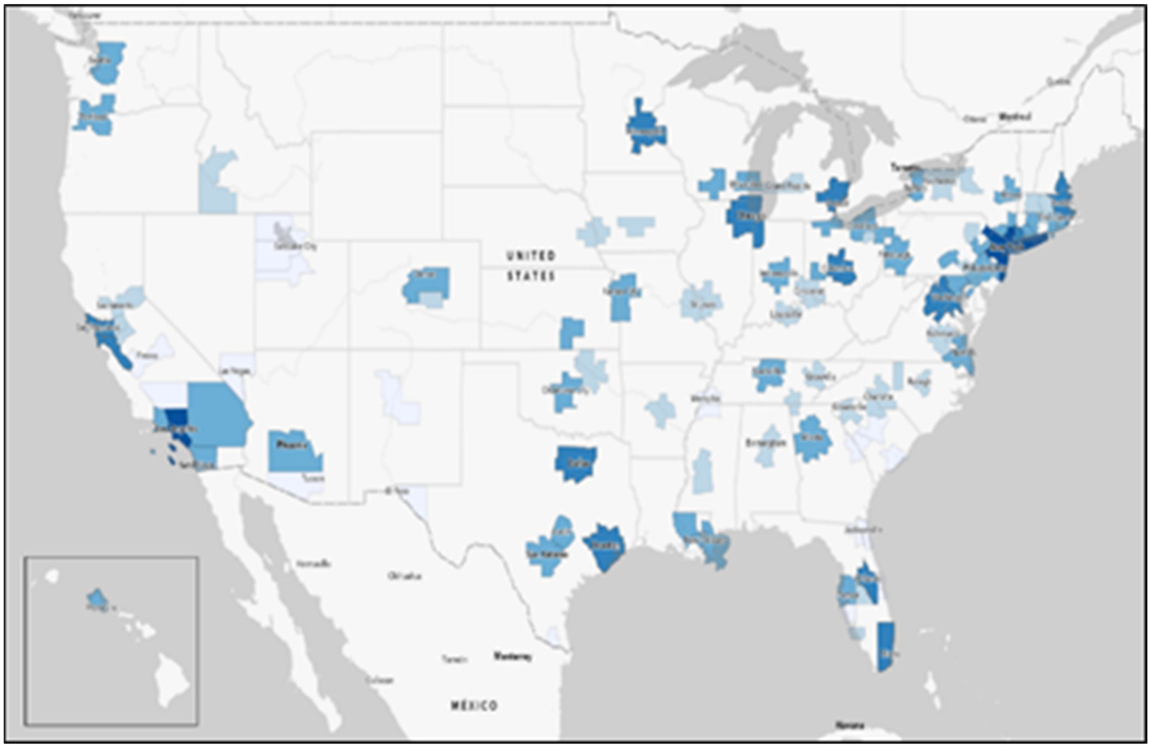
[97] Many metropolitan areas in the US and elsewhere have more than one centers of activities. For example, Washington DC metro have Baltimore to the north, District of Columbia at the core and multiple city centers in the northern Virginia in the south and southwest. Similar examples of polycentricism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



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

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

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

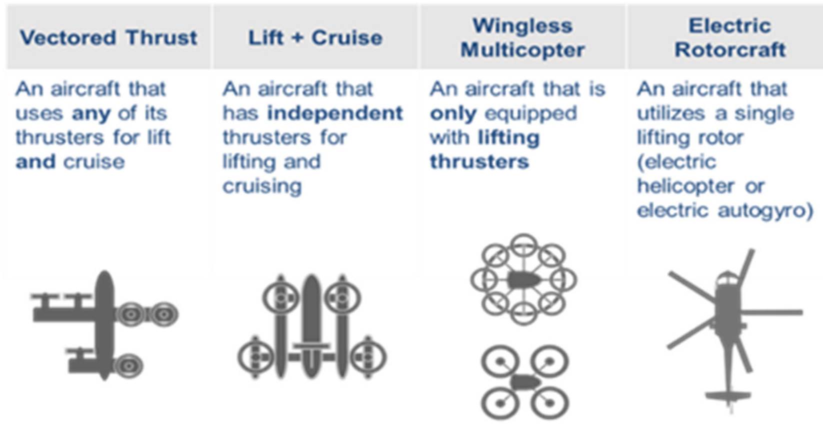


Matching the above metros against the expressed interests of the AAM OEMs and likely operating partners, mostly gathered via public statements, ASSURE identifies the following 5 likely areas of initial operations:[100]

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

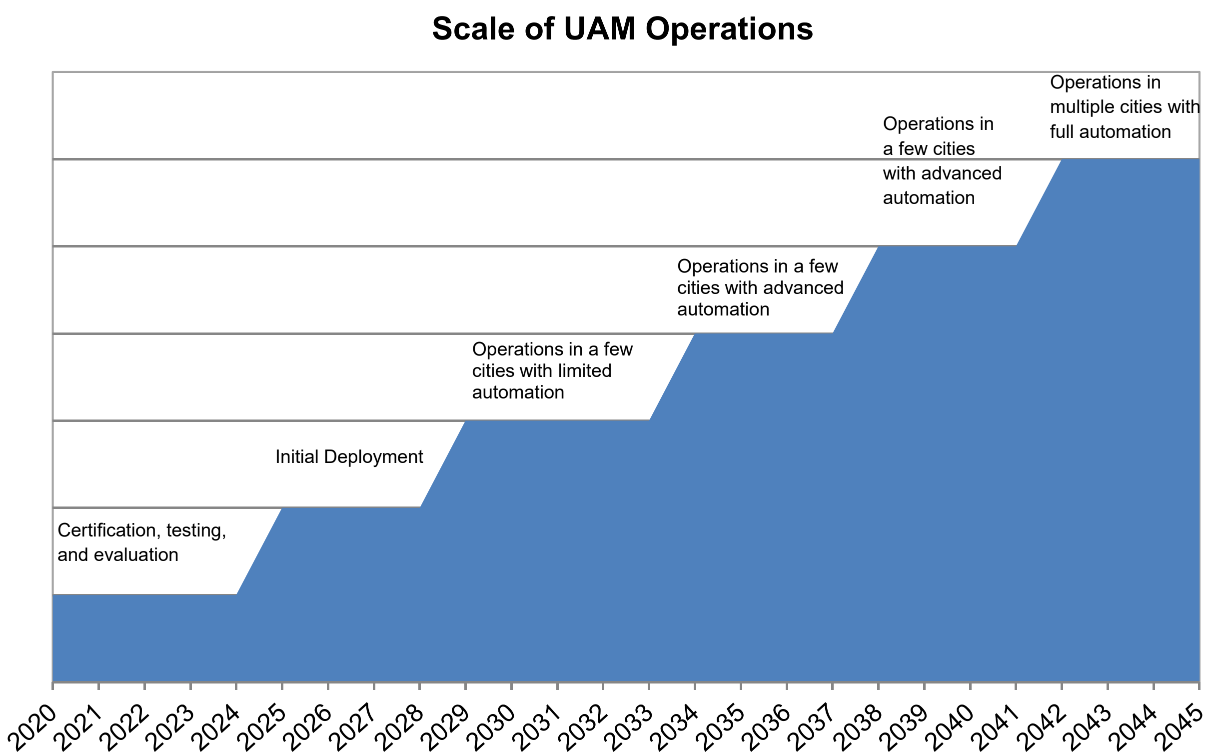
Broadly speaking, there are four types of AAM aircraft that are likely to enter into services, as reported by the ASSURE research. These are aggregated into following 4 categories:

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



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

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



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

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

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

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

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

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

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

			Departure Forecasts*			
	Year1	Year2	Year3	Year4	Year5	Year6
	2025	2026	2027	2028	2029	2030
Base	295,530	494,637	827,887	1,385,657	2,319,213	3,881,730
Low	206,871	346,246	579,521	969,960	1,623,449	2,717,211
*': Base (risk-adjusted potential) is based on linear interpolation of ASSURE forecasts;						
Low forecast is 30% lower than base forecasts.						

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

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

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

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

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

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

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

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

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

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

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

Passenger Flow* Corresponding to Departures

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

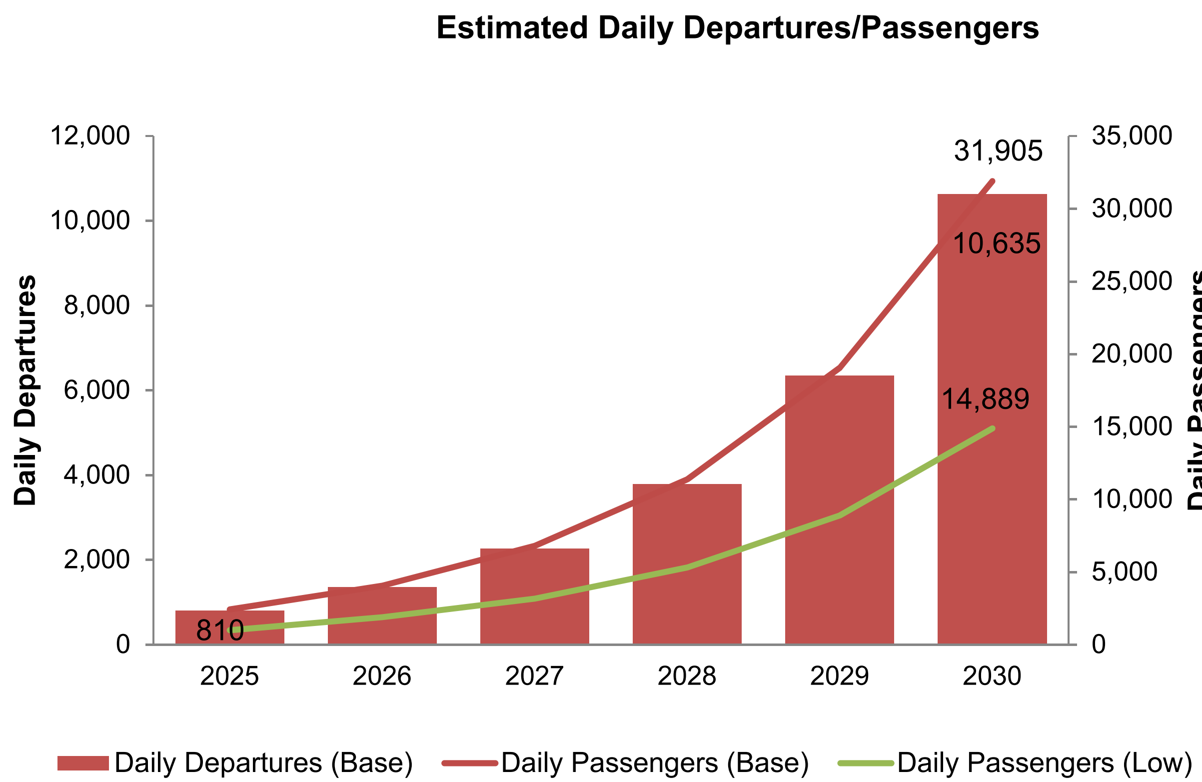
*: 3 passengers per departure and 2 passengers per departures corresponding to base and low forecasts, respectively.

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

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

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

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



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

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

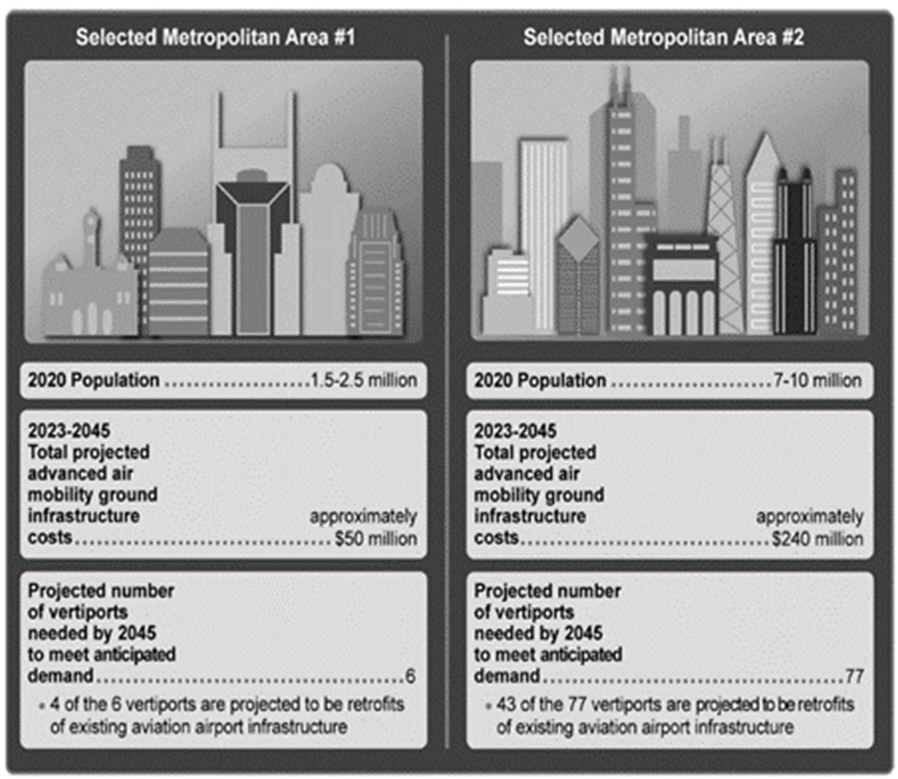
[114] See https://bit.ly/2C57w77 for this calculation. Not all of these trips, either commute to work or visiting friends/families, can be substituted by AAM air taxis. It merely indicates the size of the substitution magnitude for calculating latent demand for AAM.

[115] https://bit.ly/3m0vfPL.
[116] See https://ushst.org/.

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

[125] See https://bit.ly/3ZBg9xP.

[126] See https://bit.ly/3zwB6PL for more details.

[127] UAM Market Study – Technical Out Brief, Oct. 2018, Booz-Allen-Hamilton and NASA. [See https://go.nasa.gov/3GjAYa1. See also Goyal *et. al.* (2021) reported earlier]

[128] https://bit.ly/3Ku0xaV.

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

[130] See https://bit.ly/3ZMllPb. Furthermore, Blade with existing services in many parts of the country including the NYC reported first successful completion of a historic piloted test flight of BETA's ALIA-250 electric and vertical aircraft (EVA) at the Westchester County Airport in White Plains, New York on February 14 this year. Blade reported it to be a significant milestone towards transition from its use of helicopters to EVA in the near future [see https://bit.ly/3lZgAUY for more details].

[131] Research studies, industry reports and analysis tend to suggest a broad range of price estimates with varying effects on AAM demand: $2.25 per seat mile to as much as $11 per seat mile as summarized and reported here: https://bit.ly/3KySwS6.

[132] Road congestion and associated opportunity cost in commuting around metro areas provided the most powerful boon for economic and financial justifications for AAM passenger services. However, changed working pattern due to working from home (WFH) caused by COVID19 put a damper on that earlier economic trade-off, at least in the near-term. McKinsey reported results of a survey from last year (2022) of workers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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