Unmanned Aircraft Systems

Unmanned aircraft systems (UAS) have been experiencing healthy growth in the United States and around the world over the past few years. Last year has been no exception despite the profound impact of COVID-19 on the overall economy. A UAS consists of an unmanned aircraft and its associated elements—including the aircraft, the control station, and the associated communication links—that are required for safe and efficient operation in the national airspace system (NAS). While introduction of UAS in the NAS has opened up numerous possibilities, commercial in particular, it has brought operational challenges including safe integration into the NAS. Despite these challenges, the UAS sector holds enormous promise; potential uses include modelers flying for recreational purposes to delivering packages on a commercial basis; including the delivery of medical supplies; and provision of support for search and rescue missions following natural disasters and other public service uses.

This section provides a broad overview covering recreational and commercial (or Part 107) unmanned aircraft[13] and their recent trends as gathered from trends in registration, surveys, overall market, and operational information. Using these trends and insights from industry, the FAA has produced a number of forecasts. Forecasts reported in the following sections are driven primarily by the trends in registrations, assumptions of the continuing evolution of the regulatory environment, the commercial ingenuity of manufacturers and operators, persistent recreational uses, and underlying demand for UAS services.

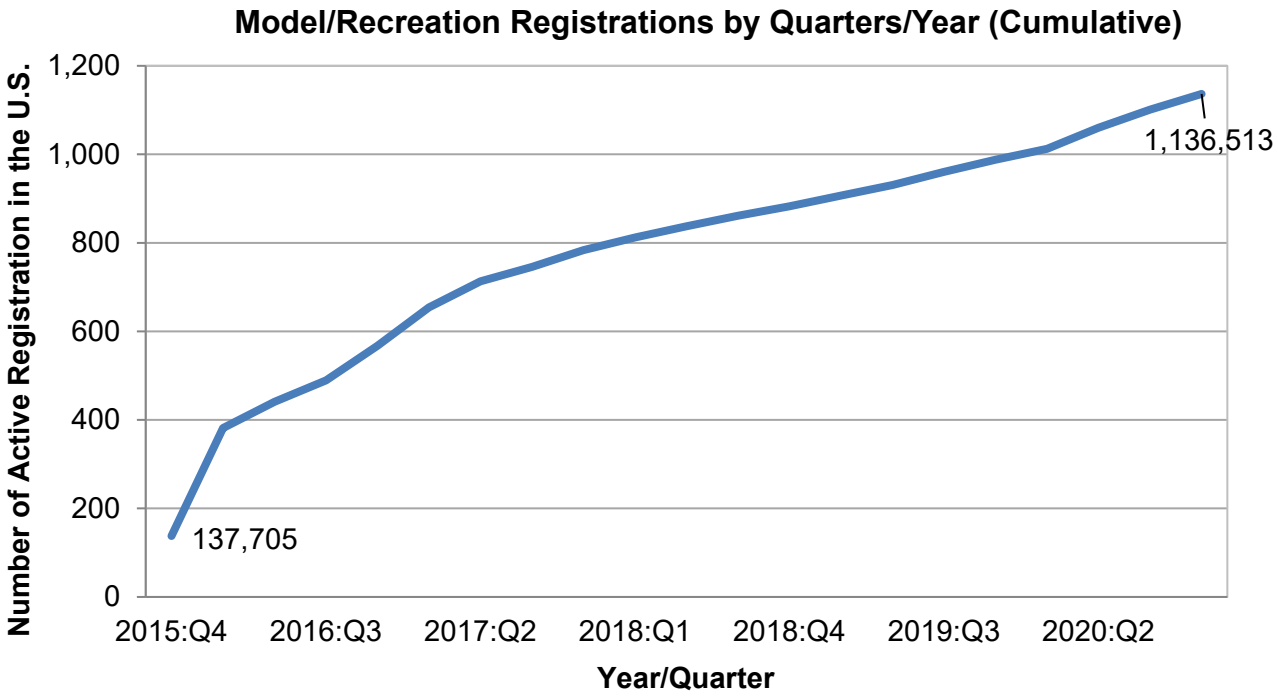
Trends in Recreational/Model Aircraft and Forecast

FAA's online registration system for recreational/model sUAS went into effect on Dec. 21, 2015. This required all UAS 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 (https://www.faa.gov/uas/getting_started/registration/) 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, D.C. in May, 2017 (i.e., *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]. NDAA extended the registration for three

[13] These are also called, interchangeably, hobby and non-hobby 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://www.federalregister.gov/documents/2019/05/17/2019-10169/exception-for-limited-recreational-operations-of-unmanned-aircraft for more details]. Recreational fliers, under Section 349, are referred to as "recreational fliers or modeler community-based organizations" [seehttps://www.faa.gov/uas/recreational_fliers/]. In previous notes including other documents of the Agency, these terms are often interchanged.

years for those registered prior to December, 2017. Registration pace continued after the temporary halt was removed. On October 5, 2018, the President signed the FAA Reauthorization Act of 2018 that formalized new conditions for recreational use of drones [See https://www.faa.gov/news/updates/?newsId=91844 for more details].

With the continuing registration, almost 1.14 million recreational UAS owners had already registered with the FAA by end of November, 2020.[14] On average, owner registration stood at around 12,400 per month during January-December, 2020 with some expected peaks during the holiday seasons and summer.

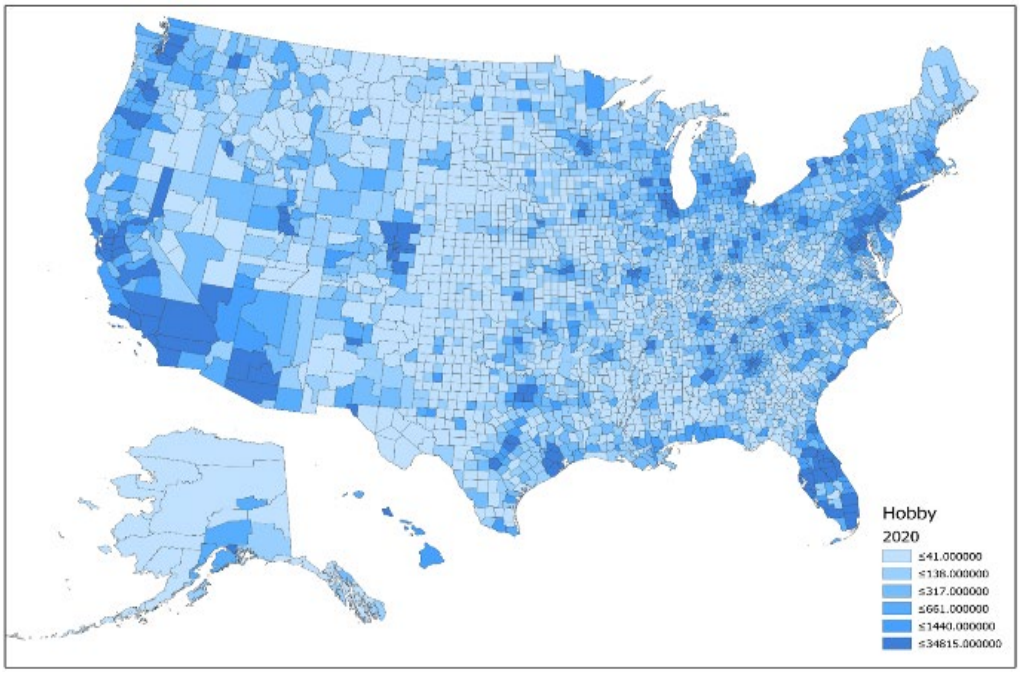


The current pace of registration has increased compared to last year in the same period; average monthly owner registration during 2020 stood 3,000 more than the level observed in 2019.

Recreational registration, and thus ownership of sUAS, is distributed throughout the country. Using the data available in December 2020, a spatial distribution of ownership by zip code below demonstrates that sUAS continue to be distributed throughout the country with denser ownership mapping

[14] 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 U.S. and the territories. Furthermore, we use those registrants who are "active;" i.e., those whose registrations have been canceled or withdrawn are not part of the data we report in this document. Finally, using the trends for the prior months in 2020 and years before, we extrapolate it to December, 2020 for completion of annual data.

closely against the population centers of the country, as expected.



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

With around 1.14 recreational operators registered as of December, 2020, we estimate that there are around 1.44 million fleet distinctly identified as recreational aircraft. Comparing with industry sales and other data noted above, we conclude that the number of recreational aircraft is almost 30% higher than ownership registration.[15]

[15] This calculation involves taking into account retirement, redundancy, and loss of aircraft corresponding to ownership registration. As aircraft become sturdier and operators situationally aware, we expect this rate to change dynamically over time. Assumptions tying ownership to aircraft holding and issues related to compliance have

A comparison of last year's data (2019) with this year's (2020) shows the annual growth rate to be approximately 8.5%. This was possible due to continuation of drones playing dominant roles in recreation that is facilitated by decreasing equipment prices (e.g., average price around $750 or less), improved technology such as built-in cameras and higher capability sensors, and relatively easy maneuvering. Furthermore, it appears that COVID-19 had a positive impact on recreational registration (see below for more details). Nevertheless, similar to all technologies fueling growth of hobby items (e.g., cell phone and video game consoles; and prior to that, video cameras and video players), the trend in recreational sUAS 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 recreational eagerness plateaus.

Given the trend in registration and market developments, we forecast that the recreational sUAS market will saturate at around 1.55 million units. However, there is still some upside uncertainty due to further changes in technology including battery, faster integration from a regulatory standpoint, and the likely event of continued decreasing prices. This leads to upside possibilities in the forecast. In contrast, there is relatively less low-side uncertainty. Low-side uncertainty tracks closer to the base forecast. We provide a forecast base (i.e., likely) with high and low scenarios, provided in the table below.

Last year, we forecasted that the recreational sUAS sector would have around 1.38 million sUAS in 2020, a growth rate exceeding 4.5% from the year before (2019). Actual data overshot the projection by a little over 53,000 with over 1.44 million aircraft already accounted for by the end of 2020. Thus, our forecast of recreational sUAS last year undershot by 3.7% for 2020; or 1.4365 million actual aircraft vs 1.3833 million aircraft that we projected last year.

Total Recreation/Model Fleet (Million sUAS Units)

Fiscal Year	Low	Base	High
Historical			
2020	1.4365	1.4365	1.4365
Forecast			
2021	1.4544	1.5022	1.5417
2022	1.4668	1.5303	1.5935
2023	1.4708	1.5415	1.6157
2024	1.4719	1.5455	1.6237
2025	1.4724	1.5510	1.6347

been discussed elsewhere [see https://www.napawash.org/studies/academystudies/federal-aviation-administration-assessment-of-compliance-with-and-effective for a recent study by the National Academy of Public Administration on these issues].

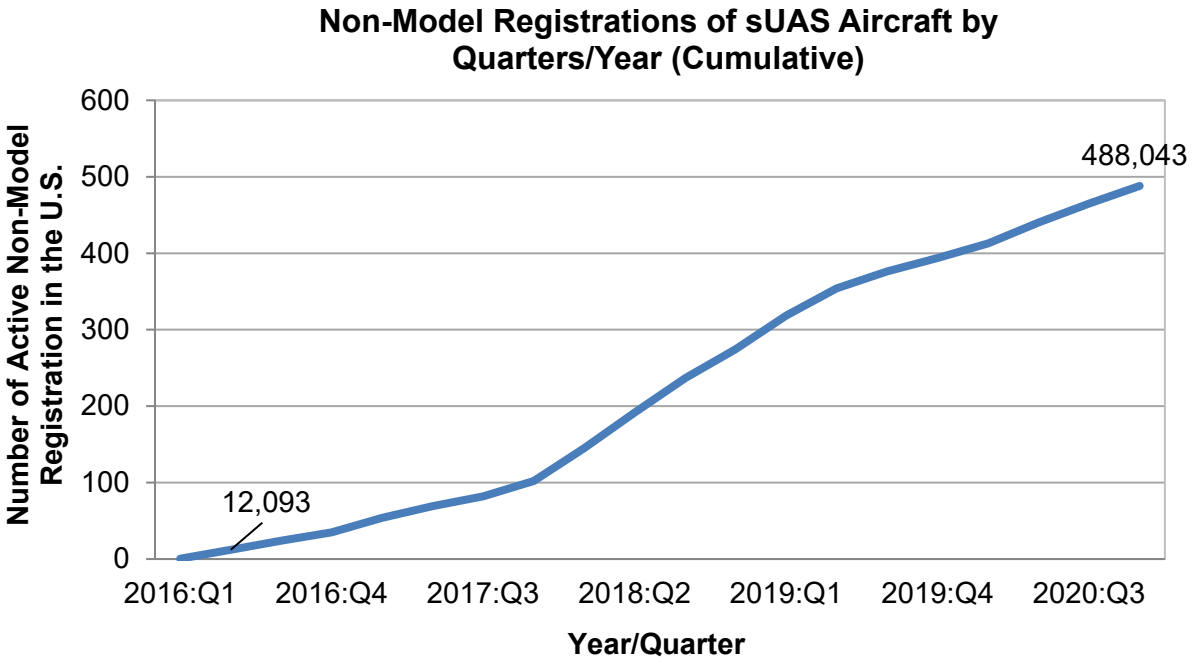
The FAA uses the trend observed in registrations, particularly over the past year; expert opinions distilled from TRB annual workshops; review of available industry forecasts; market/industry research; and a time-series model on registration trends fitted on monthly data. Using these, we forecast that the recreational sUAS fleet will likely (i.e., base scenario) attain its peak over the next 5 years, from the present 1.44 million units to around 1.55 million units by 2025. The high scenario may reach as high as 1.63 million units with low-side scenario yielding around 1.47 million units over the next 5 years. Notice that eventual saturation at somewhat higher levels, in comparison to last year's projections, reflects relatively higher registration by recreational flyers observed during 2020. This increased registration trend, in part driven by COVID-19, may or may not continue in the longer run[16]. Nevertheless, the growth rates underlying these numbers are fairly steady in the initial years, but fade faster in the last 2-3 years. The gradual saturation that is projected in 5 years and beyond in the recreational sUAS fleet parallels other consumer technology products and the Agency's projections from last year.

Trends in Commercial/Non-Model Aircraft and Forecast

Online registration for commercial/non-model sUAS went into effect on April 1, 2016. Unlike recreational/model ownership, rules for commercial registration require owners to register each sUAS, thus creating a one-to-one correspondence between registration and aircraft. During the period of January – December, 2020[17], more than 94,000 commercial operators registered their equipment. The pace of monthly registration, slightly above 7,800, is still relatively high but lower than the same period in 2019 (around 10,000). It appears that the pace of registration is slowing down in comparison to 2019 and comparable historically (i.e., April 2016 – November 2019 roughly 8,500 per month). While the pace of recreational registration ownership has increased somewhat, particularly last year, the pace of registration remains somewhat dampened for their commercial counterparts. By the end of 2020, there were more than 488,000 commercial UAS registered since the registration opened.

[16] It is quite likely that many people are buying and experimenting with recreational sUAS given the COVID-19 public health emergency and a substantial portion of the workforce is presently working from home. This may or may not continue once regular work patterns are resumed.

[17] As noted in fn. #2, using actual registrations until November, 2020, trends for the prior months in 2020 and years before, we extrapolate it to December, 2020 for completion of yearly data.

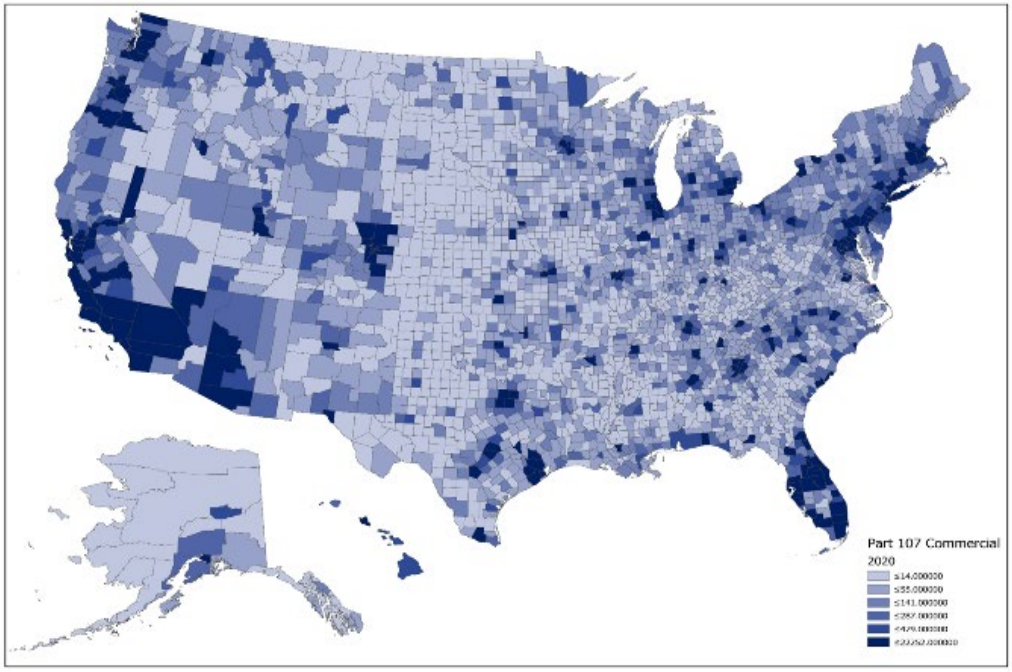


For each month the registration has been available, over 4,600 aircraft/month were registered until December, 2017. This pace accelerated to 14,600 registered per month during 2018. During 2019, average monthly registration stood at around 10,100. In the past year of 2020, average monthly registration dropped to 7,850. Despite this slowdown, the commercial sUAS sector is dynamic and appears to be at an inflexion point demonstrating powerful stages of growth. Unlike the recreational sUAS 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 has, and continues to provide, to the industry. In particular, the Operation Over People final rule, published on December 28, 2020, is the latest incremental step towards further integration of sUAS 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 [seehttps://www.faa.gov/news/media/attachments/OOP_Executive_Summary.pdf for more details].

The Remote ID rule was announced on December 28, 2020 [seehttps://www.faa.gov/news/media/attachments/RemoteID_Final_Rule.pdf] as well. Remote ID (i.e., digital license-plate) of unmanned aircraft is necessary to ensure public safety and efficiency of the airspace of the United States. The rule applies to all operators of 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. Under the present rule guidance, unmanned aircraft in flight is to provide, via broadcast, certain identification, location, and performance information that interested parties on the ground and other airspace users can receive.

There are three ways to comply with the Remote ID rule: (a) operate a standard remote ID sUAS broadcasting identification and location information of both the aircraft and control station; (b) operate a sUAS with a remote ID broadcast module attached to it that broadcasts identification, location and takeoff information; and (c) operate a sUAS without Remote ID but flying at specific FAA-recognized identification areas (or FRIAs) [see https://www.faa.gov/uas/getting_started/remote_id/]. The final rule was been published in Federal Register on January 15, 2021, and almost all of the final rule goes into effect on April 21, 2021[seehttps://www.federalregister.gov/documents/2021/01/15/2020-28948/remote-identification-of-unmanned-aircraft as amended byhttps://www.federalregister.gov/documents/2021/03/10/2021-04882/remote-identification-of-unmanned-aircraft-delay].

These two rules together 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, one such place for receiving all operational information, including registration, authorization, and logging accident reports, helps facilitate this growth further [https://faadronezone.faa.gov/#/].



As in the case of recreational UAS ownership, commercial sUAS are distributed across the country. A spatial distribution of equipment registration (using data for December 2020) demonstrates that commercial sUAS are distributed throughout the country with denser activities mapping closely against the economic or commercial activities of the country.

Last year, the FAA forecasted that the commercial UAS sector would have around

507,000 sUAS in 2020, a growth rate exceeding 32% over the year before (2019). Actual data came close to that projection with a little over 488,000 aircraft by the end of 2020. Our forecast of commercial sUAS last year thus overshot by 3.7% for 2019 (or 488,043 actual aircraft vs 506,776 projected last year). Forecasting in a time of tremendous uncertainty is indeed challenging, especially given the economic slowdown during COVID-19 and its impact on the UAS sector. The commercial sUAS sector's fast growth and adjustments during the pandemic is a demonstration of that fact. Nevertheless, our forecast errors for both recreation and commercial appear to be within the bounds of reasonableness.

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

Fiscal Year	Low	Base	High
Historical			
2020	488	488	488
Forecast			
2021	543	589	691
2022	569	665	871
2023	583	729	1,028
2024	601	784	1,094
2025	614	835	1,144

We use the trends observed in the registration during the years past, information from the survey conducted in 2018, review of available industry forecasts/workshops and past FAA UAS Symposiums, and internal research together with market/industry research. Using these, the FAA forecasts that the commercial UAS fleet by 2025 will likely (i.e., base scenario) be at around 835,000; 1.7 times larger than the current number of commercial sUAS.[18] As the present base (i.e., the cumulative total) increases, the FAA anticipates the growth rate of the sector will slow down over time. Nevertheless, the sector will be much larger than what was only a few years earlier.

In order to understand the growth trajectory of the sector better, this report divides the commercial UAS sector into two types of sUAS aircraft: consumer grade and professional grade. The consumer grade commercial UAS 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.[19] For both consumer grade and professional grade UAS, the average price is falling over time, particularly over the last few years. Currently, the consumer grade dominates the commercial

[18] Last year, the ratio of end-year forecast to base year forecast was 2-times; i.e., we forecasted end-year to be twice the base year's (2019) numbers in 5-year (2024).

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

UAS sector with a market share approaching 92%. However, as the sector matures and the industry begins to consolidate, the share of consumer grade commercial UAS is likely to decline though it will still be dominant. By 2025, FAA projects this sub-sector will have approximately 87% of the overall commercial sUAS sector.

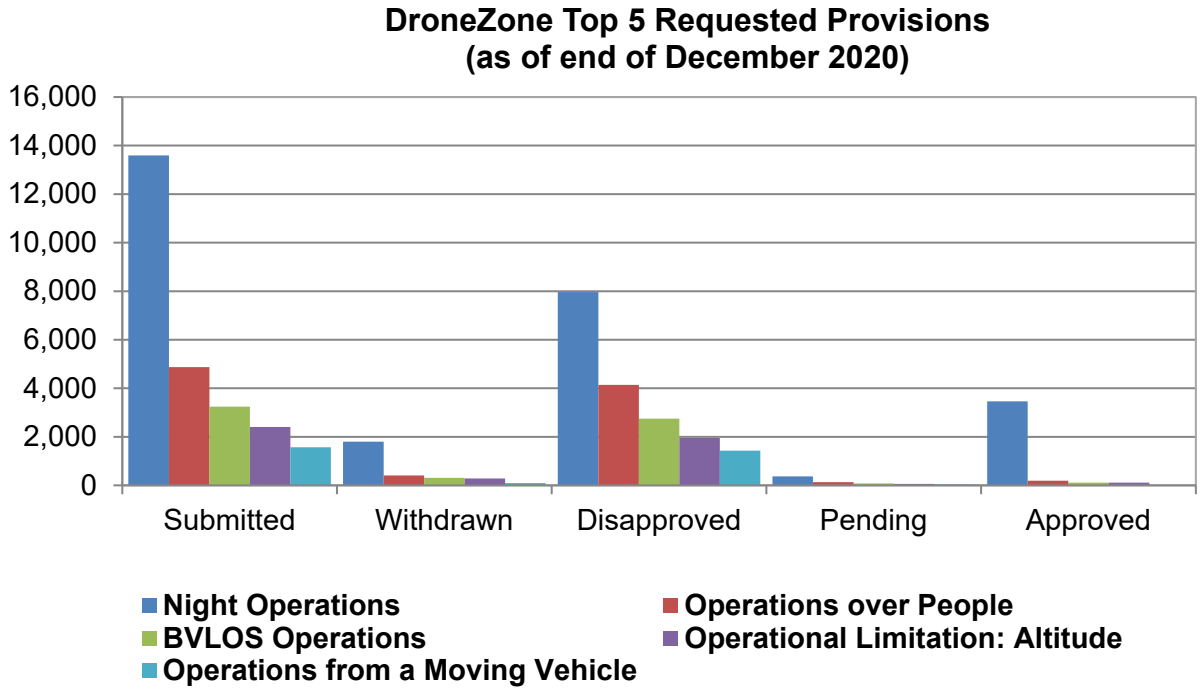
Starting from a lower base of approximately 40,000 aircraft in 2020, the professional grade commercial sUAS sub-sector stands to expand rapidly over time reaching 105,000 in 2025, especially as newer and more sophisticated uses are identified, designed, and operationally planned and flown. If, for example, professional grade sUAS meet criteria of operations, safety, regulations, and satisfy economics and business principles and enter into the logistics chain via small package delivery, the growth in this sector will likely be phenomenal. On the other hand, starting from a base of 448,000 in 2020, consumer grade sUAS is likely to grow over 730,000 by 2025. These growth trajectories could be even further enhanced by expanding operations in controlled airspaces, e.g., the Low Altitude Authorization and Notification Capability (LAANC) system[20], which began authorization in May, 2017. LAANC is designed to facilitate sUAS use of controlled airspace in the NAS. While most of the near-term growth in commercial sUAS will continue to come from consumer-grade units (over 90%), the FAA anticipates a significant part will come from professional-grade sUAS as well.

Unlike its recreational sUAS counterpart, it is extremely difficult to put a floor on the growth of the commercial sUAS sector due to its composition (i.e., consumer vs. professional grades) and the varying business opportunities and growth paths. As commercial sUAS become operationally more efficient and safe, battery life expands, and regulatory constraints are gradually relaxed (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, search-and-rescue operations, just to name a few) that are somewhat latent and in the experimental stages at present. Unlike a developed sector such as passenger air transportation, it is impossible to put a marker on "intrinsic demand" (or core demand) primarily driven by economic and demographic factors underlying this sector. Nevertheless, in this year's forecast the FAA makes a provisional attempt to provide a "low" side for now, essentially capturing the intrinsic demand. 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 11% and 19%, respectively. Average annual growth rate corresponding to the low scenario, on the other hand, is around 5%.

[20] Low Altitude Authorization and Notification Capability [https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/] or LAANC automated the application/approval process for airspace authorizations. Requests submitted via FAA approved UAS Service Suppliers (USS) are checked against airspace data in the FAA UAS Data Exchange such as temporary flight restrictions (TFRs), Notice to Airmen (NOTAMS), and the UAS Facility Maps (UASFM). Approved requests thus provide the FAA/ATO visibility into where and when planned drone operations will take place.

Commercial sUAS 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 sUAS as is increasingly evident, for example, from the successful implementation of the UAS Integration Pilot Program (IPP) [see https://www.faa.gov/uas/programs_partnerships/integration_pilot_program/ for more details].

One way of identifying early trends in commercial sUAS use is to analyze the waiver applications granted to sUAS operators. Both the magnitude and relative composition of waiver types may indicate the direction of the commercial sUAS sector as a whole. A breakdown of the waiver requests granted in December, 2020 is shown in the chart below:

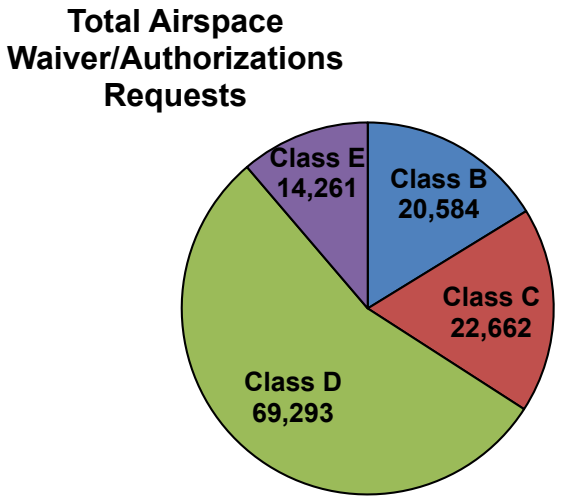


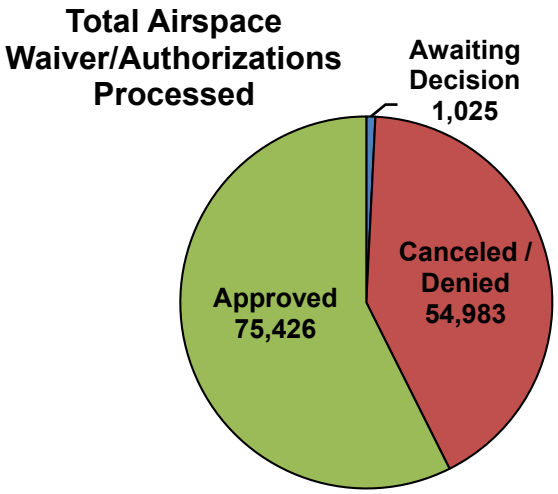
Beyond the daytime operation that is presently allowed under existing Part 107 rules, expanding applications further requires waivers, to a large extent, for night operations as distinct from daylight operations (around 9 in 10 approved waivers), and operations over people (around 1 in 20 approved waivers). As noted earlier, approved rules will now allow night operations and some operations over people as part of routine operations no longer requiring waivers. There are also BVLOS waiver requests (around 13% of total requests) and limitations on altitude (around 9% of total requests), for which waiver approvals are given at rates of 2.8% and 2.9%, respectively. Many of these waivers are combined, and thus total waiver approvals (i.e., full + partial) granted (over 3,890 by December, 2020) exceed 100%.

The Agency issues these waivers to facilitate business activities by sUAS while preparing for the next round of regulations that will enable routine, more complex drone opera-

tions. Now that night operations and operations over people have been finalized[21] [see https://www.faa.gov/news/media/attachments/OOP_Final%20Rule.pdf] amending Title 14 of the Code of Federal Regulations Part 107 (14 CFR Part 107) by permitting the routine operation of sUAS at night[22] or over people under certain conditions[23], the Agency is turning its focus on long-term solutions that will eventually enable routine BVLOS fights without waivers. Analysis of the waiver applications allows us to understand industry trends, one of many metrics essential for understanding and projecting the trajectory, course corrections, and growth trends of the sector.

On the airspace authorizations and waivers, almost 50% of requests were approved for controlled airspace at the end of December, 2020. While over half were for class D airspace (i.e., smaller airports with control towers), other classes were also requested and regularly flown.





Finally, LAANC has been routinely providing auto-approval since its inception in May, 2017, and now covers 726 airports. It has provided 289,749 auto-approvals for airspace access requests from Part 107 users

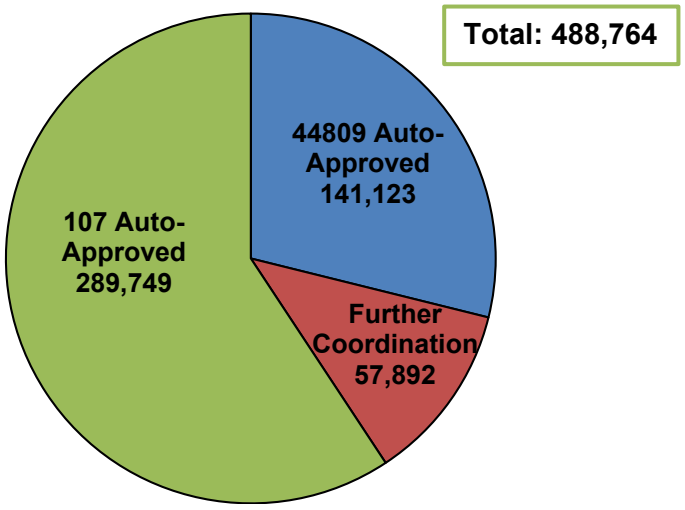
[21] The rule has been sent to the Office of the Federal Register and will become effective 60 days after the publication date in the Federal Register. Publication was expected in January 2021 but effective dates were delayed [See: https://www.federalregister.gov/documents/2021/03/10/2021-04882/remote-identification-of-unmanned-aircraft-delayandhttps://www.federalregister.gov/documents/2021/03/10/2021-04881/operation-of-small-unmanned-aircraftsystems-over-people-delay-withdrawal-correction.

[22] *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*).

[23] *See* § 107.39. An operation over people was established as one in which a small unmanned 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.

and 141,123 requests from recreational operators as defined by 49 U.S.C. §44809[24]. Approvals thus total over 430,000 (see below); over 200,000 more since this time last year, while sending almost 58,000 requests for further coordination. LAANC authorizations are facilitated by the use of UAS facility maps (UASFM) [https://faa.maps.arcgis.com/apps/webappviewer/index.html?id=9c2e4406710048e19806ebf6a06754ad] that provide maximum allowed altitudes around airports where the FAA may authorize Part 107 UAS operations without additional safety analysis. The UAS facility maps are used to inform requests for Part 107 airspace authorizations and waivers in controlled airspace.

LAANC Airspace Requests



Status of Survey

The FAA is expected to conduct a nationwide survey of UAS operators in the summer of 2021, titled *Survey of UAS Operators*. The survey would ask commercial, recreational, and safety-agency operators in the United States about flight behavior, fleet characteristics, and commercial activities. To achieve this goal, all UAS operators who have registered with the FAA and have a valid email address will be invited to participate in the survey. The responses to the survey are intended to help the FAA make more informed decisions regarding UAS policy, investment in UAS infrastructure, and public safety in local communities

In general, the survey will ask all operators about flight behavior and their sUAS fleet. Questions about flight behavior include how often they fly their sUAS, the duration of each flight, how high they fly, and which days of

[24] Strictly for recreational uses [see https://www.faa.gov/uas/recreational_fliers/new_changes_recreational_uas/media/44809_authorization.pdf].

the week and months of the year they are the most active. The questions about operators' sUAS fleets includes propulsion type, weight of aircraft, and number of aircraft. The survey responses will allow the FAA to develop models of sUAS activity in the NAS, which should inform both policy and investment.

In addition to the general flight and fleet questions, two additional sections are included for respondents who self-identify as commercial or safety-agency operators. The commercial operator's section asks questions about industry of operation and intentions to apply for waivers. The safety-agency operator's section asks questions about intra-agency cooperation and training activities.

The new information collect request (ICR) for the survey is in the final stages of approval from the Office of Management and Budget (OMB). Both the 60-day notice and comment (www.regulations.gov/document?D=FAA-2020-0488-0001) and the 30-day notice and comment (www.regulations.gov/document?D=FAA-2020-0488-0003) have been completed. In addition, the ICR has received approvals from both the FAA's Paperwork Reduction Act (PRA) office and the Office of the Secretary of Transportation (OST). The FAA expects OMB approval before the summer of 2021.

Once the ICR is approved, the FAA will initiate an awareness campaign for the survey. The awareness campaign will include emails to operators registered with the FAA and social media posts through FAA social media accounts.
In addition, a webpage with information about the upcoming survey will be published on the FAA website.

After the survey closing, the responses to the survey will be compiled and appropriately weighted. The statistics developed from the survey will be published in the Aerospace Forecast, like in the past, the year after the survey has been completed. We expect to publish those results in the near future.

Remote Pilot Forecast

An important final metric in commercial sUAS is the trend in remote pilot (RP) certifications. RPs are used primarily to facilitate commercial sUAS flights. As of December 2020, approximately 206,347 RP certifications have been issued[25], an increase of around 47,000 from the same time last year.

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

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

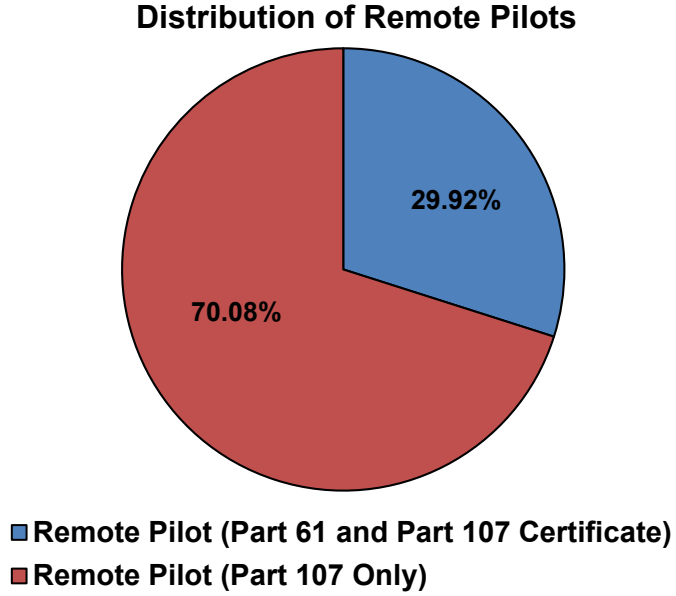
has completed the necessary TSA security background check. This email contains instructions for printing a copy of the temporary remote pilot certificate from IACRA. A permanent remote pilot certificate is sent via mail once all other FAA-internal processing is complete. A RP certificate is valid for 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 sUAS.

Certifications for Part 61 operators, on the other hand, require that an applicant must hold a pilot certificate issued under 14 CFR Part 61, and must have completed a flight review within the previous 24 months. Since Part 61 airmen 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, proof of current flight review, and 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. (See https://www.faa.gov/uas/commercial_operators/become_a_drone_pilot/ for more details).

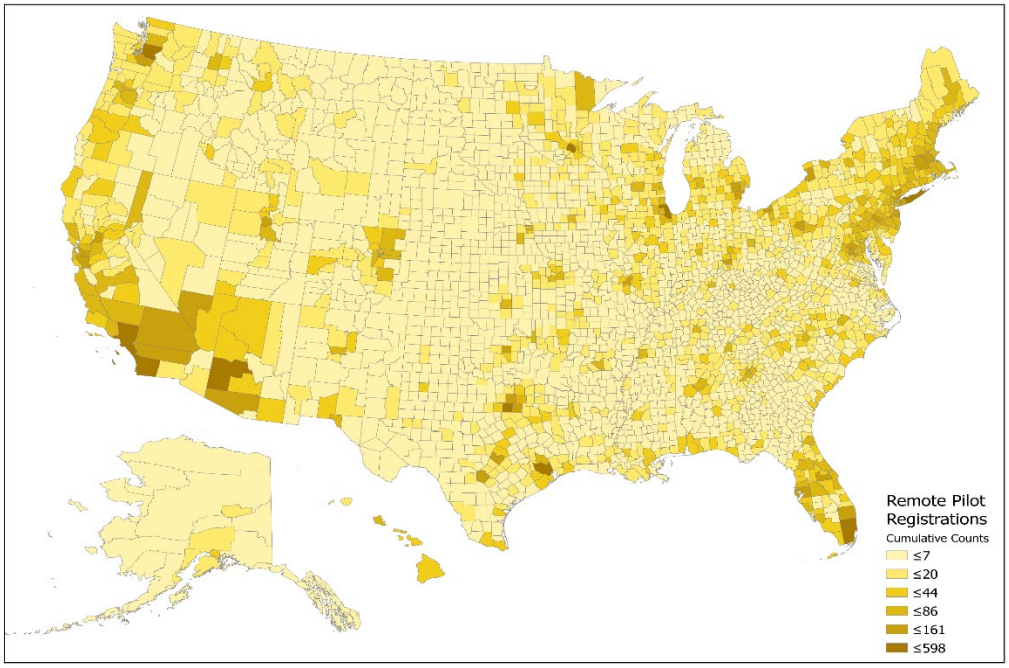
Following the process above, the FAA classifies RPs into two categories:

- 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.

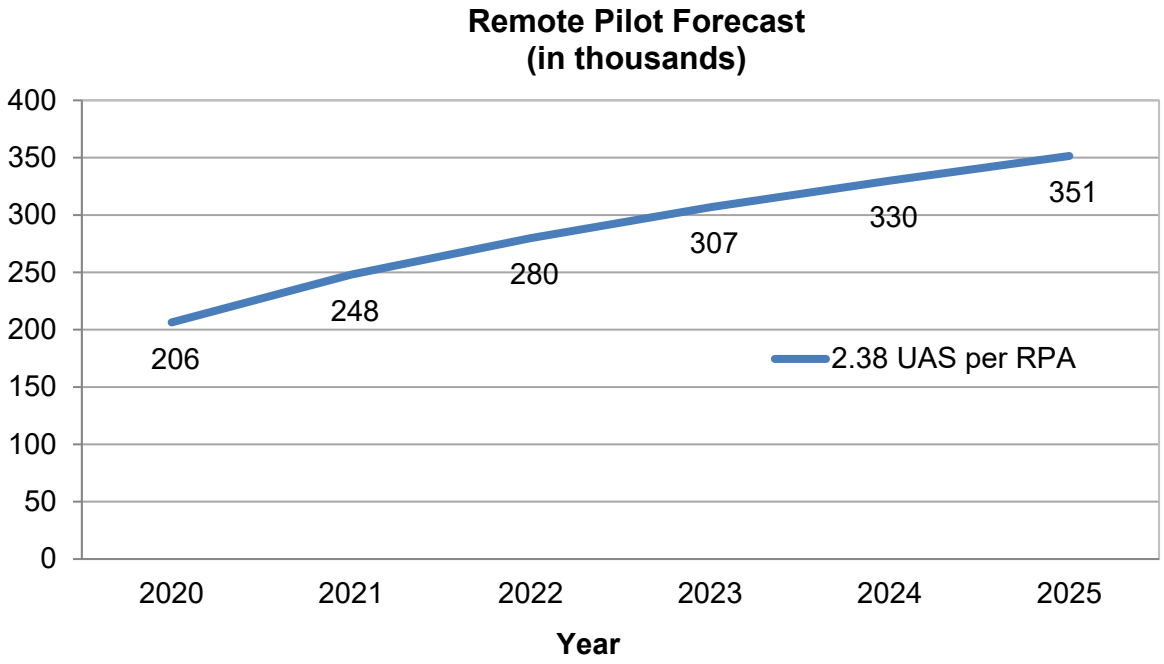


Over 70% of the RPs are part 107 RPs only. Over 90% of those who took the exam passed and obtained RP certification. A cumulative density distribution of remote pilots by zip code in 2020 is provided in the map below.



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 sUAS registration and forecasts of fleet. Given the trends in registration and our forecast of the commercial UAS fleet, the FAA assumes that one pilot is likely to handle 2.38 units of commercial sUAS aircraft, same as last year.

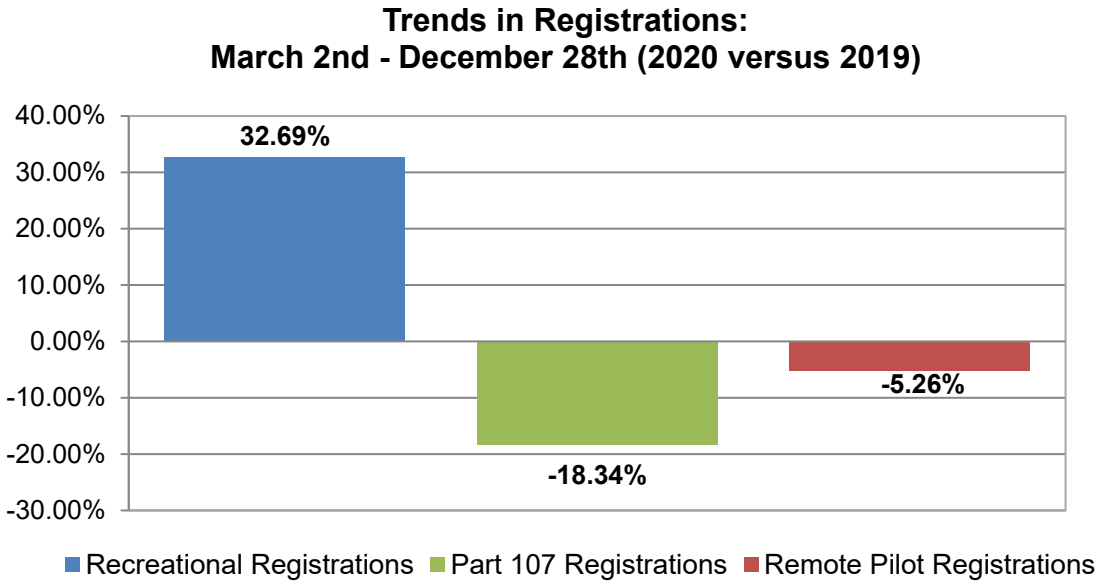
Using these assumptions and combined with the base scenario of the commercial sUAS forecast, we project RPs in the graph below. Last year, the FAA projected RPs to be around 213,200 by the end of 2020. Actual registrations came to be 206,347 or falling short of 3.21% from the projection last year.



Given the actual numbers at the end of 2020, RPs are set to experience tremendous growth following the growth trends of the commercial sUAS sector. Starting from the base of 206,347 RPs in 2020, commercial activities may require almost 350,000 RPs in 5 years, a 1.7-fold increase, providing tremendous opportunities for growth in employment associated with commercial activities of sUAS. Potential for RPs may enhance even more if larger UAS are used in commercial activities and advanced air mobility (AAM) becomes a reality in the near future.

COVID-19 and Its Impact on sUAS

Before we turn our attention onto areas of further expansion of sUAS, the chart below summarizes how COVID-19 may have impacted three areas of registration. During the prolonged shut-down (i.e., March-Dec, 2020) of numerous parts of the economy, we notice that commercial facets of sUAS, i.e., Part 107 and RP registrations, were impacted negatively.

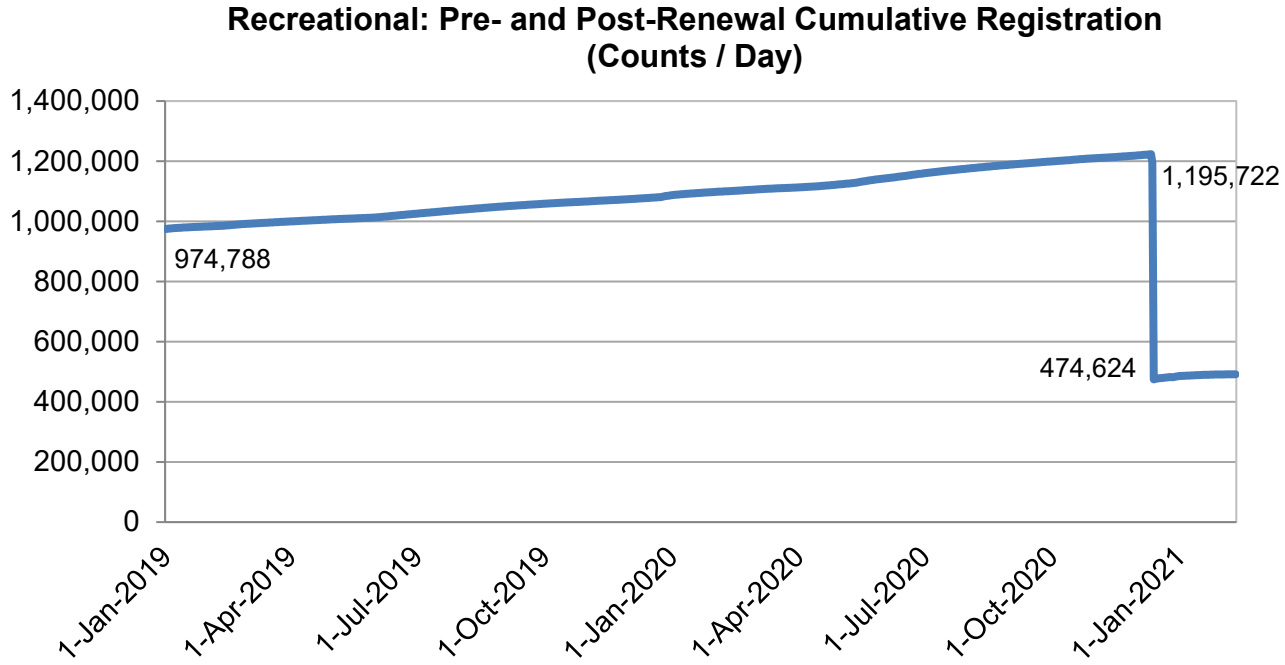


As evident, Part 107 registrations dropped by over 18% during this long period of partial shut-down in 2020 in comparison to the year before. RP registrations, on the other hand, dropped by around 5%. Interestingly, the registrations of recreational users went up by almost 33% during this past year in comparison to the year before. While it is quite possible that these drops/increases were led by sectoral progression, we believe that at least parts of the observed drops/increase were caused primarily by COVID-19. As the economy slowed down considerably, use of commercial sUAS and correspondingly the use of RPs, may have dropped as a result. On the other hand, economic slowdown may have afforded more time to people working from home; consequently, leading to increased experiment of recreational uses of sUAS thus causing higher registration in this past year in comparison to the year before.

Effective/Active Fleet via Renewal

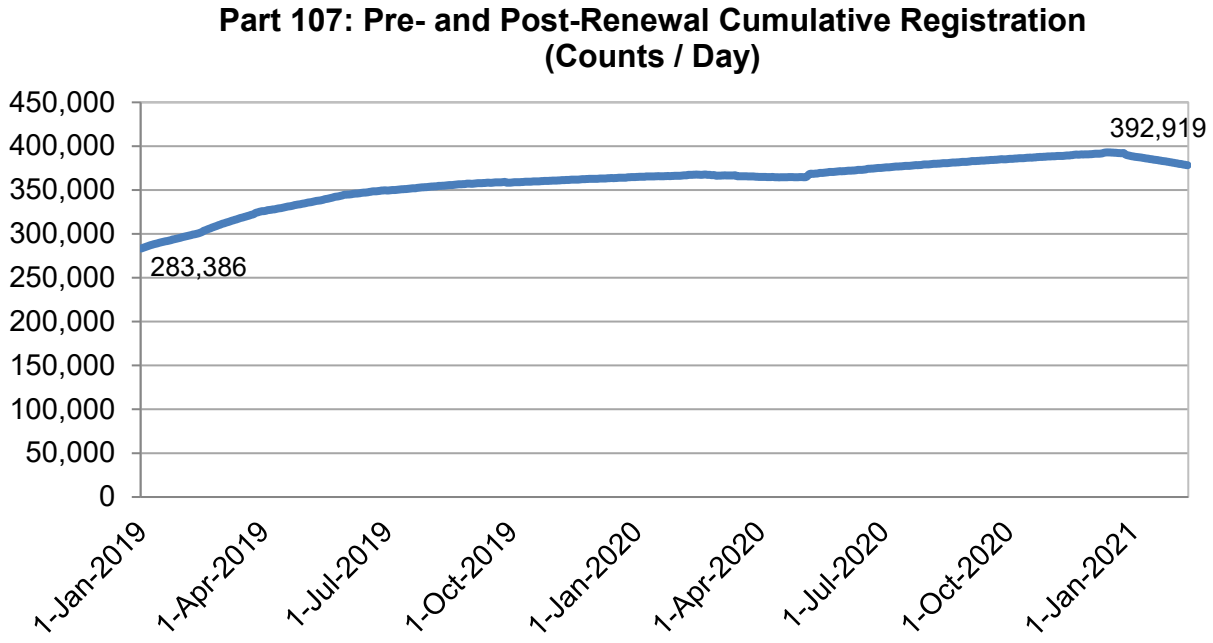
sUAS are registered for 3 years [see https://www.faa.gov/uas/getting_started/register_drone/] while RP certifications are valid for 2 [seehttps://www.faa.gov/uas/commercial_operators/become_a_drone_pilot/]. As noted earlier, rules adopted by the FAA in the matter of registration and marking requirements for sUAS aircraft [see FAA-2015-7396; published on December 16, 2015] were vacated by the United States Court of Appeals for the District of Columbia Circuit in *Taylor v. Huerta* [No. 15-1495; decided on May 19, 2017]. However, Section 1092(d) of the NDAA for Fiscal Year 2018 (Pub. L. 115-91), signed by the President on December 12, 2017, overruled the decision in *Taylor v. Huerta* and reestablished FAA's authority over registration. The FAA 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 for both recreational and Part 107 registrations. As a result of this sequence of events, approximately 800,000 sUAS registrations were due for renewal in December 2020.

The beginning of the registration renewal affords the FAA an opportunity to review the data, i.e., duplicates and unnecessary registrations removed, and make the registration database cleaner and more compact. Following this process, a preliminary examination of the data reveals that renewal of registrations appears to be slower perhaps due to inertia, an informational awareness gap, confusion about registration duration, and/or lack of operational opportunities. This is particularly true for recreational registrations. For example, a comparison of the latest period for which preliminary data is available against the earlier periods, i.e., December 13-February 10 for 2019-2021, show renewal and data clean-up led to a significant decline, over 60% (or over 721,000) in cumulative recreational registration trends.



This decline occurs due to renewal/data and validation starting on December 13, 2020. Average daily registrations, taking into account renewal, for the latest period shows a decline of 11,934 compared to over 300 daily registrations in the two years prior during the same periods (see the figure above). Further examination will occur during the upcoming year.

Part 107 renewal trends, on the other hand, leading to restating of registrations show similar trends but declines are much less prolific compared to its recreational counterpart.



Average daily registrations taking into account renewals dropped to -248, as opposed to earlier positive numbers, during the same periods of Dec. 13 – February 10 in different years since the registry began. Renewal/data clean up beginning on December 13, 2020 led to a reduction of over 14,600 from the cumulative registration counts by February 10 this year. We do not observe similar trends in RP registrations following renewals.

Given the uncertainty underlying these numbers (e.g., effect of undecideds/late decision by registrants to renew, role of registrations initiated by third -party services), this opens up a great need for communications about the registration renewal requirement, which the Agency already initiated. Furthermore, FAA's decision to defer the registration renewal process for 800,000 registrants, collected over approximately a year and a half period, created a unique data anomaly with regard to the renewal process. This data anomaly may be further skewed by confusion about registration requirements and practices of third-party registration services that occurred during this period. Now that registration is expiring on a routine basis, FAA will begin to monitor this data point carefully.

While removal of registrations that have been entered in error may reduce the total number of registrations, it is likely that renewals by late deciders may significantly alter cumulative numbers and upward. As noted earlier, the Agency uses registration as the primary basis for forecasting. Upon careful review of these data, which appear to be transitory, we decided not to use these changes in data to drive forecast for this year. We are examining these numbers carefully and will report the renewal-driven registrations and forecasts based on the stabilized numbers in the near future. For this year, we continue reporting registration trends prior to Dec. 12 and extrapolated data for forecasts (see fn. #s 2 and 5). Provided that this slow pace is indeed due to inertia, and not due to changed opportunities or lost interests, renewal trends may have significant impact on effective fleet

in the NAS and thus remaining integration challenges and opportunities.

IPP to BEYOND

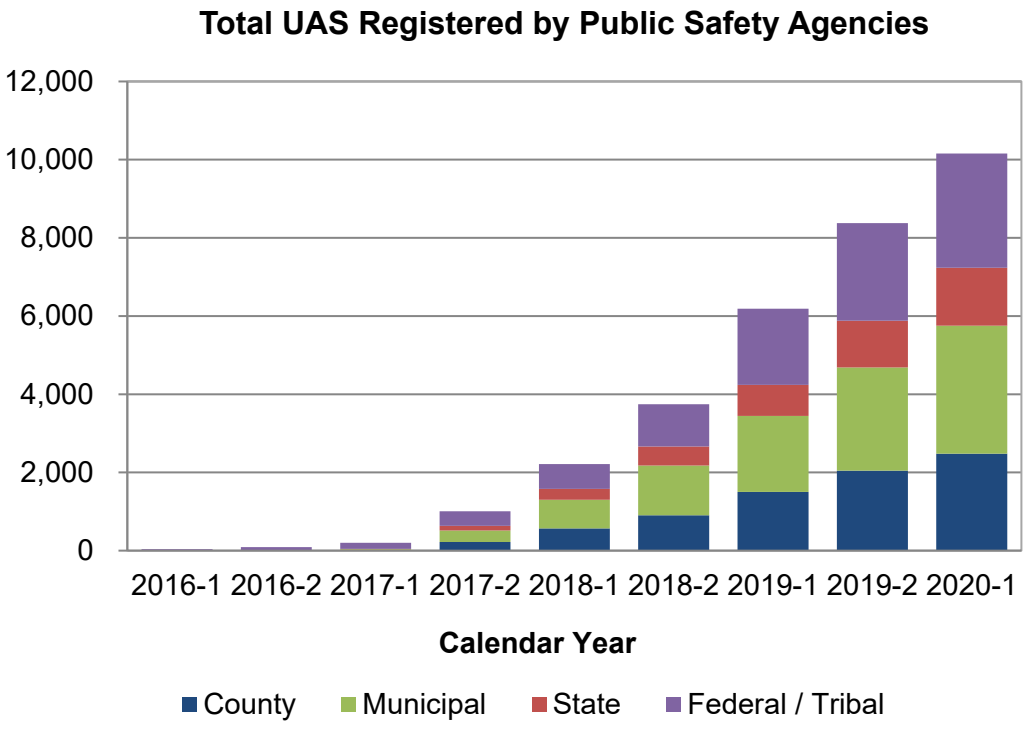
One such integration challenge was addressed under the Unmanned Aircraft System (UAS) Integration Pilot Program (IPP). Beginning in 2017, the IPP brought state, local, and tribal governments together with private sector entities, such as UAS operators or manufacturers, to test and evaluate the integration of civil and public drone operations into the NAS. The IPP program [see https://www.faa.gov/uas/programs_partnerships/integration_pilot_program/ for more details] concluded on October 25, 2020. The FAA launched a new program called BEYOND to continue working on specific challenges of UAS integration:

- Beyond Visual Line of Sight (BVLOS) operations that are repeatable, scalable and economically viable with specific emphasis on infrastructure inspection, public operations and small package delivery;
- Leveraging industry operations to better analyze and quantify the societal and economic benefits of UAS operations; and
- Focusing on community engagement efforts to collect, analyze and address community concerns.

BEYOND started on October 26, 2020 to continue the partnerships with eight of the original nine IPP participants. [see https://www.faa.gov/uas/programs_partnerships/beyond/ for more details].

sUAS use by Public Entities

Public safety agencies' use of sUAS has grown over time and will continue to grow. Public safety agencies' roles in the United States include law enforcement, firefighting and response to natural disasters, and emergency medical services. Additionally, these agencies are at different levels of government: federal, state, and local including tribal and territorial. Examples include the Department of the Interior monitoring wildlife with sUAS; California Fire using sUAS for firefighting operations; and local police departments using them for search and rescue in missing person instances. Figure below shows the historical growth of sUAS. By mid-year 2020, 2,399 public safety agencies had an active fleet size of 10,156 based on FAA Part 107 registrations [see Figure below].



Future growth of public safety agencies' sUAS fleet size will continue to be strong. Table below outlines the different growth paths for the next five years. The expectation is that the sUAS fleet size will be over 30,000 by 2025. This reflects a compound annual growth rate of 24 percent. The strength of growth will depend on multiple factors. One factor is changes in FAA regulations for sUAS, such as allowing tactical beyond visual line of sight. Another factor is budgetary constraints at local and state levels of government. These factors have the possibility of increasing or decreasing the growth of sUAS adoption from public safety agencies as shown in Table below with High and Low forecasts.

Fiscal Year	Low	Middle	High
Forecast			
2021	11,733	14,127	15,604
2022	13,022	18,098	21,313
2023	14,112	22,069	27,497
2024	15,056	26,040	34,106
2025	15,888	30,011	41,102
CAGR*	9%	24%	32%

Note: Based on extrapolation of registrations of Part 107 UAS by public safety agencies 2018-2020.

*Compound Annual Growth Rate

Large UAS

UAS weighing 55 pounds or greater cannot be operated under part 107 or as recreational unmanned aircraft. These larger UAS (lUAS) must be registered using the existing aircraft registration process and operated with an exemption under the Special Authority for Certain Unmanned Systems (49 U.S.C. §44807) or a public aircraft operator (PAO) certification. At present, many of these aircraft fly within the NAS by federal agencies including the Departments of Defense (DoD), Homeland Security (DHS), Interior (DOI), Energy (DOE), and Agriculture, as well as NASA, state governments, local governments, and academia. However, commercial operators are on the rise, many of which are operating agricultural lUAS. In order to calculate active lUAS in the NAS, we employ multitudes of data from various sources: the COA Online system and its successor CAPS or COA Application Processing System; MITRE's Threaded Track infusing data from different sources, FAA's Performance Data Analysis, FAA's Aircraft Registry and Reporting Systems or PDARS; and Notices to Airmen (NOTAM).

Combining these data sources, the FAA estimates that 195 lUAS are operating in 2020, with the bulk of these aircraft operated by the DoD and other government agencies. However, these estimates are likely the lower bound since a growing number of agricultural lUAS are operating in close proximity to the ground (i.e., likely below 400ft AGL) and are not captured by this data. These agricultural lUAS are likely to grow rapidly over the next 5 years but will have very little effect on air traffic in the NAS given their locations away from busy manned air traffic and low altitude.

lUAS operated by military and civilian agencies in the NAS are expected to grow at a steady pace over the next 5 years. DoD is expected to remain the largest operator of lUAS in airspace above 400ft AGL over the forecast.

However, commercial operators are expected to overtake government operators as a whole over the next 5 years. As the industry for agricultural UAS matures, farmers are expected to switch from manual or manned aircraft spraying to lUAS for their specialty crops. This switch should drastically increase the number of lUAS operated for commercial reasons, but unlike the lUAS operated by the government, these lUAS are operating well below 400ft AGL.

In 2020, 14 exemptions were granted by the FAA for commercial UAS with weights above 55lbs while 21 exemptions expired. There are approximately 30 active exemptions to operate a lUAS. One-third of the active exemptions are for agricultural uses, mostly with UAS weighting above 55lbs. The exemptions for agricultural spraying is likely to increase as the technology and the industry matures.

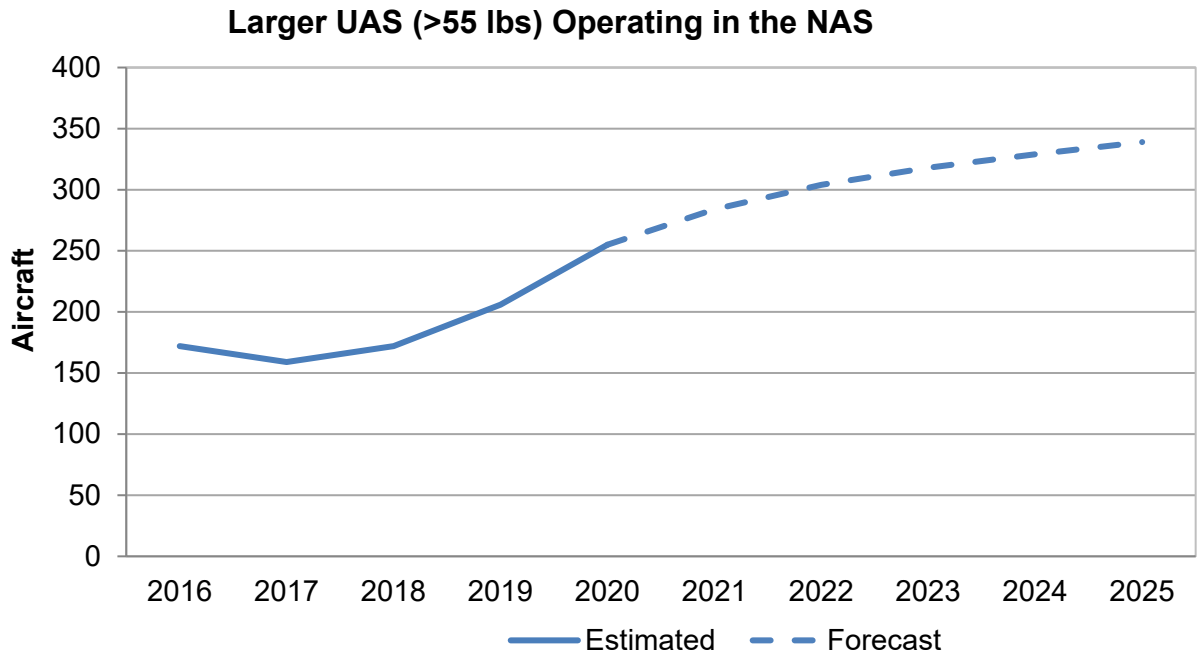
The unmanned aircraft over 55lbs registered in the public aircraft registry has increased by 63 percent, from 322 at the end of 2019 to 510 at the end of 2020. Three hundred and nine lUAS registered or renewed in 2020, up 21 percent from 2019. However, the delisted and expired registration almost tripled in 2020 from 47 deregistration in 2019 to 121 deregistration in 2020. Around 10 percent of the lUAS registered are directly connected to agricultural uses.

Although 510 lUAS are registered in the public aircraft registry, only a portion of these aircraft are currently operating commercially. A sizable portion of the lUAS operators are not operating their aircraft in the NAS due to safety or regulatory concerns or only operating close to the ground. As such, the number of registered lUAS which are likely to come in contact with ATC is small. The forecast for the lUAS is only for aircraft operating in airspace where contact with other lUAS or manned aircraft is possible.

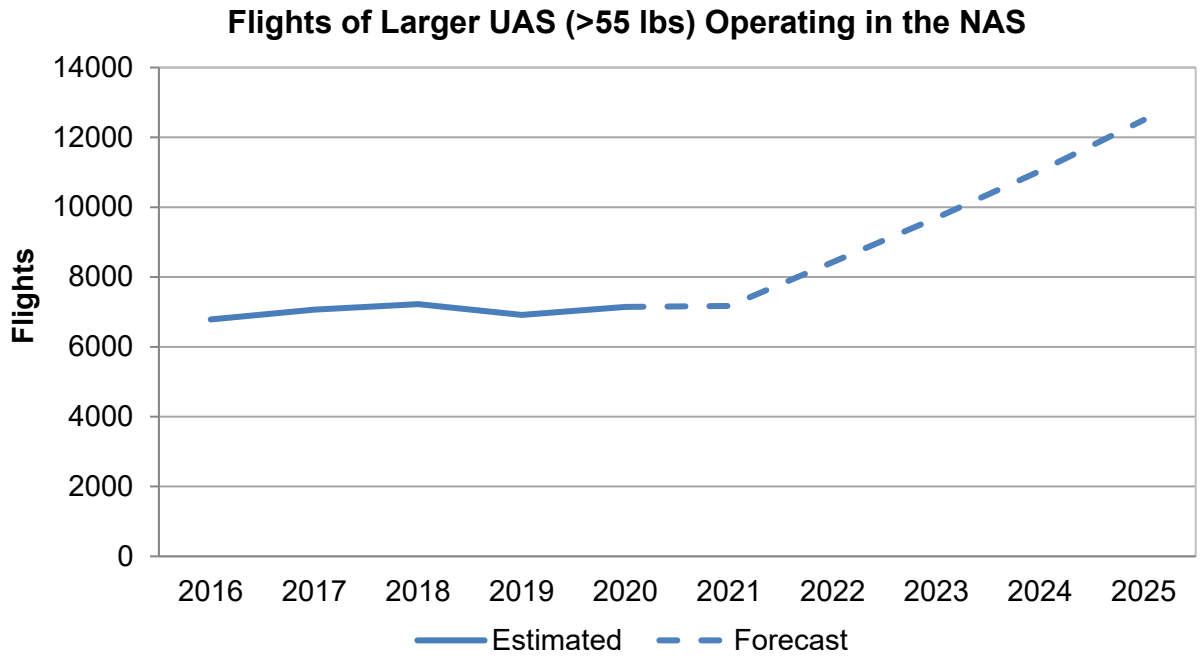
Larger UAS (>55 lbs) Forecast - 5 Years

Year	Active L-UAS	Number of Flights
Historical		
2016	172	6,785
2017	159	7,066
2018	172	7,223
2019	206	6,914
2020	255	7,144
Forecast		
2021	284	7,171
2022	304	8,426
2023	318	9,696
2024	329	11,038
2025	339	12,500

Combining the baseline from military and civilian agencies and projections of commercial exemptions from the FAA, lUAS are estimated to increase from 209 in 2019 to 255 in 2020, and are expected to increase by 29 aircraft in 2021 due to an acceleration in commercial applications. As commercial and advanced military lUAS are introduced over the next half decade, lUAS are projected to increase to 339 aircraft by 2025. The flattening of the forecast from previous years is partially due to the sunset of UAS exemptions under 49 U.S.C. §44807 in September of 2023, which is expected to reduce the fleet of lUAS after 2024, and partially due to the economic impact from Covid-19, which has drastically reduced the utilization of these aircraft.



Despite 49 additional aircraft detected operating in the NAS in 2020, only 230 additional flights were observed. This suggests that the utilization of each IUAS had decreased since the beginning of the Covid-19 pandemic recession. Even though the IUAS fleet is expected to increase in 2021, lower utilization of each aircraft is expected to keep flights relatively unchanged. As economic activity recovers and planned IUAS accusation are fulfilled, flights are expected to grow rapidly, despite fewer new IUAS. As such, the number of IUAS flights are expected to increase from the estimated 7,144 in 2020 to 12,500 by 2025, even as the growth of the IUAS fleet stabilizes.



Advanced Air Mobility

In September 2017, NASA launched a market study for a segment crossing over some functions of UAS discussed above. This segment of autonomous vehicles broadly called Advanced Air Mobility[26] (or AAM) is defined as "a safe and efficient system for air passenger and cargo transportation, inclusive of small package delivery and other urban UAS services, which supports a mix of onboard/ground-piloted and increasingly autonomous operations" (See https://www.nasa.gov/aero/nasa-embraces-urban-air-mobility). AAM technology presents considerable opportunities for economic growth over the coming decades. Markets for AAM services, such as delivering packages by drone or larger unmanned cargo or unmanned passenger shuttles or air taxis, have huge potentials both in the United States and globally. For example, package or larger cargo delivery is the AAM service that is most likely to experience economic growth in the next decade. By 2030, for example, 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.[27]

[26] The community is in the process of deciding on a nomenclature. Only recently, the community-at-large has moved onto 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.

[27] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. (See https://www.nasa.gov/uamgc.)

Passenger services, on the other hand, promise larger markets for AAM services, but safety challenges and evolving technology leading to market uncertainties may slow the pace of AAM's penetration into this segment of the market. It appears that initial AAM operations will be more likely helicopter operations with pilots onboard leading to some form of automation as vehicles mature. Due to perceived uncertainties, market estimation for the overall sector has been quite wide. 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 one study estimates.[28] On the upside of the estimation, a recent study conducted by Deloitte and the Aerospace Industries Association (AIA) estimates[29] 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. 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.

Airport shuttles and other fixed-route passenger services are the AAM passenger services most likely to gain economic traction in the coming decade. Optimistic reports project the AAM passenger industry to have 23,000 aircraft with 740 million enplanements per year at a price of around $30 per trip by 2030.[31] However, several other studies have reported more conservative estimates, arguing the market penetration is likely 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.[32] Similarly, Roland Berger estimates a fleet of only 12,000 passenger UAS by 2030.[33] However,

Market dynamics underlying AAM are complex, dynamic and numerous. Although COVID-19 has led to an increased adoption of virtual work versus commuting and business travel[30], persistence of this trend in the long-run is mired in uncertainty. Socioeconomic 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, i.e., 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 due to an inflow of venture capital and experimental services exploring market opportunities.

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[28] UAM Market Study – Technical Out Brief, Oct. 2018, Booz-Allen-Hamilton and NASA. (See https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190001472.pdf.)

[29] https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/advanced-air mobility.html?id=us:2el:3pr:4diER6839:5awa:012621:&pkid=1007244

[30] Road congestion and associated opportunity cost in commuting around metros provided the most powerful boon for economic and financial justifications for AAM passenger services. However, changed working pattern and home location due to COVID19 puts a damper on that earlier economic trade-off, at least in the near-term.

[31] Urban Air Mobility (UAM) Market Study, Nov. 2018, NASA. (See https://www.nasa.gov/uamgc.)

[32] Getting Mobility Off the Ground, 2019, KPMG (see https://institutes.kpmg.us/manufacturing-institute/articles/2019/getting-mobility-off-the-ground.html).

[33] Urban Air Mobility: The rise of a new mode of transportation, Nov. 2018, Roland Berger (see https://www.rolandberger.com/en/Publications/Passenger-drones-ready-for-take-off.html).

given the current safety and technology challenges, even these projections may likely to be optimistic.

Given the enormous economic potentials underlying the AAM sector, coordination led by the Agency with close collaborations of NASA and the industry, numerous activities are presently taking place. This is leading to flight testing of AAM vehicles (e.g., https://www.nasa.gov/centers/armstrong/features/nasa-begins-air-mobility-campaign.html), regulatory coordination for safety, traffic management and on issues related to international harmonization with other agencies, e.g., European Union Aviation Safety Agency (EASA) leading to type certifications (e.g.,https://www.faa.gov/uas/advanced_operations/certification/). In order to accelerate this process, the Agency created an internal AAM Executive Council [see https://www.faa.gov/uas/advanced_operations/urban_air_mobility/] and is actively working with the internal and external stakeholders to understand the nature, scope and likely evolutions of AAM. The FAA also issued a concept of operations (CONOPS) in June last year [see https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf] and likely to publish a strategic implementation framework in the near future. NASA also launched a national campaign (NC) to promote public confidence and accelerate the realization of emerging aviation markets for passenger and cargo transportation in urban, suburban, rural, and regional environments [see https://www.nasa.gov/aeroresearch/aam/description/ for more details]. Furthermore, NASA issued AAM CONOPS corresponding to slightly advanced maturity levels (i.e., Urban Air Mobility Maturity Level 4) recently [see https://ntrs.nasa.gov/citations/20205011091 for more details].

These pro-active steps are positioning the AAM industry positively towards realizing market opportunities. In December 2020, for example, Joby Aviation received the first ever airworthiness approval by the US Air Force (USAF) for an eVTOL aircraft under Agility Prime and recently reached an agreement with the FAA to certify its aircraft using the FAA's Part 23 requirements along with special conditions for the eVTOL aircraft.[34] Joby Aviation plans to launch air taxi services in the US by 2023. Lilium GMBH, a German company, is developing an eVTOL transport network centered around Lake Nona, Orlando, Florida. It has partnered with the City of Orlando and a real estate development company to develop a vertiport hub in Lake Nona for regional, inter-city air mobility services by 2025 with travel distances of up to 186 miles in 60 minutes with Lilium Jet aircraft under development.[35]

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.[36] It also conducted demonstration flights in South Korea with its two-passenger autonomous aerial vehicle, the EHang 216. German AAM companies,

[34] https://www.aviationtoday.com/2021/02/09/joby-agrees-evtol-certification-requirements-faa/

[35] https://lilium.com/newsroom-detail/lilium-partners-with-tavistock-and-orlando

[36] https://www.ehang.com/news/617.html

Lilium and Volocopter, are also working to launch passenger air transport services in the next few years. Volocopter completed demonstration air taxi flights in Singapore in 2019 and began to sell tickets for commercial service, expected to start in Singapore by 2023.[37] 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 trade-offs underlying emergence of AAM may have changed following COVID-19, changed 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 type certification, wide production certification, and eventual community acceptance leading to greater adoption. Future AAM operators must also prepare to comply with new operating requirements and other regulations yet to come.

Despite these challenges, 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 that will evaluate barriers and solutions to launching air taxi services in Los Angeles by 2023.[38] Other entities including the Canadian AAM Consortium (CAAM) have also studied the impacts of AAM on regional economies.[39]

As the sector grows and new initiatives are undertaken, the Agency, together with numerous stakeholders, is keeping a keen eye on understanding the overall trends in AAM. As more information becomes available, the FAA will likely provide emerging trends and forecasts-in the near future.

[37] https://www.bloomberg.com/news/articles/2020-12-09/first-electric-air-taxis-set-to-fly-in-singapore-by-2023

[38] https://www.lamayor.org/mayor-garcetti-announces-first-nation-urban-air-mobility-partnership

[39] http://www.pnwer.org/uploads/2/3/2/9/23295822/economic_impact_assesment_-_caam_-_v1.0.pdf