Unmanned Aircraft Systems

Over the past few years, unmanned aircraft systems (UAS) have been experiencing healthy growth in the United States and around the world. A UAS consists of an unmanned aircraft platform and its associated elements—including communication links, sensors, software and power supply—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, it has brought operational challenges including safe integration into the NAS. Despite these challenges, the UAS sector holds enormous promise; potential uses include modelers experimenting with small UAS (sUAS) performing numerous functions such as aerial photography; recreational flying for personal uses; sUAS experimenting with package delivery on a commercial basis; delivery of medical supplies; and provision of support for search and rescue missions following natural calamities.

This section provides a broad landscape covering recreational and commercial unmanned aircraft[14] and their recent trends as gleaned from trends in registration, questionnaires, overall market, and operational information. Using these trends and insights from industry, the FAA has produced a number of forecasts. Forecasts reported in the sections below are driven primarily by the assumptions of continuing evolution of the regulatory environment, the commercial ingenuity of manufacturers and operators, and underlying. While continuing to enable the thriving UAS industry, these efforts will continue the safe integration of UAS into the NAS.

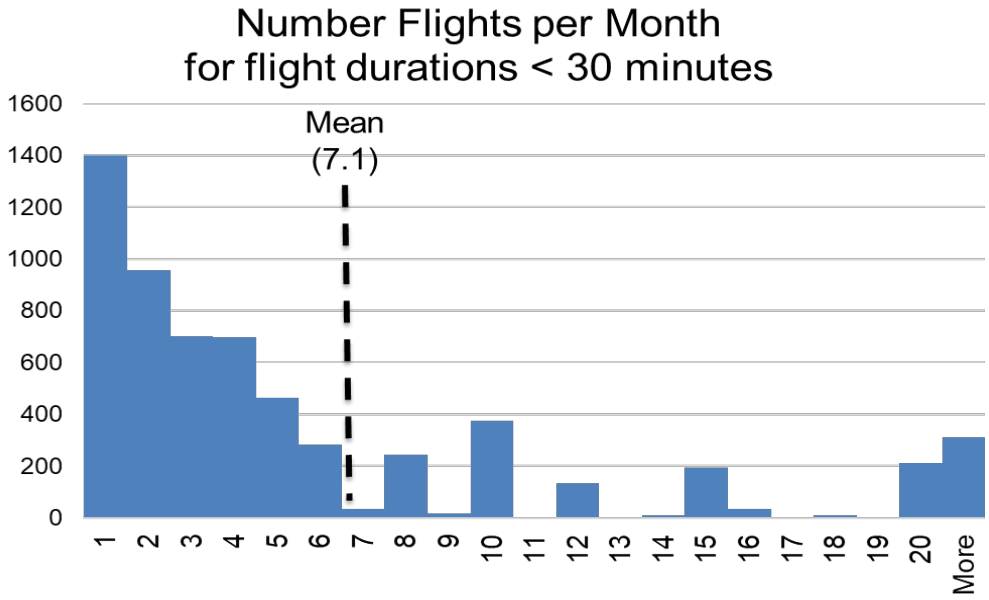
Questionnaire of Recreational/Model Registrations

Before presenting sUAS trends and forecast, this section briefly reviews the results of a proto-type questionnaire for recreational/model sUAS operations conducted during September and October of 2019. The well-tested questionnaire asked individuals registered as recreational sUAS operators under Section 349 about their flight behavior and activities, preferred method of communication from the FAA, and the UAS topics in which they are most interested. The questionnaire was anonymous, voluntary, and

[14] 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 the new conditions to operate recreational small unmanned aircraft without requirements for FAA certification or operating authority. The Exception for Limited Recreational Operations of Unmanned Aircraft established by section 349 is codified as 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 in the last authorization [see https://www.faa.gov/uas/recreational_fliers/]. In previous notes including other documents of the Agency, these terms are often interchanged.

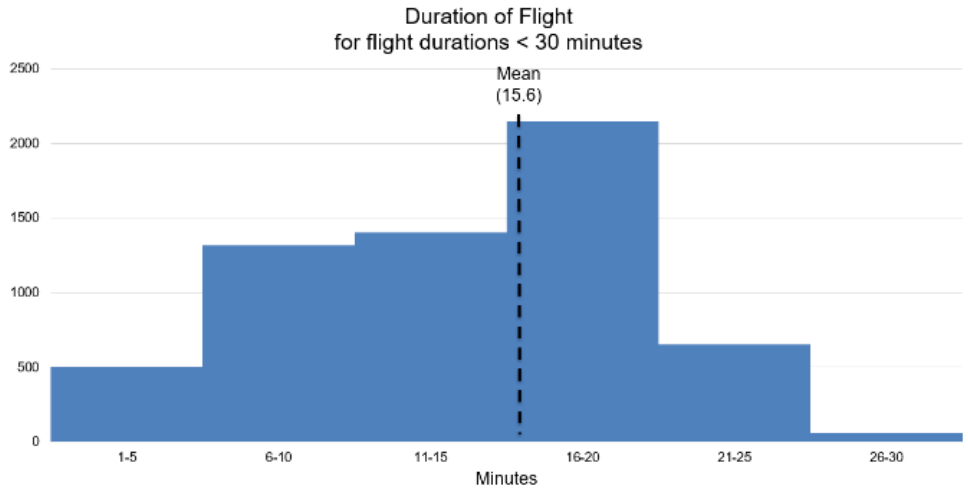
conducted over the internet. Of those registrants contacted to participate in the questionnaire, 15,482 individuals—about 6% of registrants—completed the questionnaire.

Respondents reported that, on average, they fly approximately seven flights per month after adjusting for measurement error.[15] While most respondents fly fewer than seven times per month, there are respondents who fly more often as well, with some reporting as high as 300 flights per month.

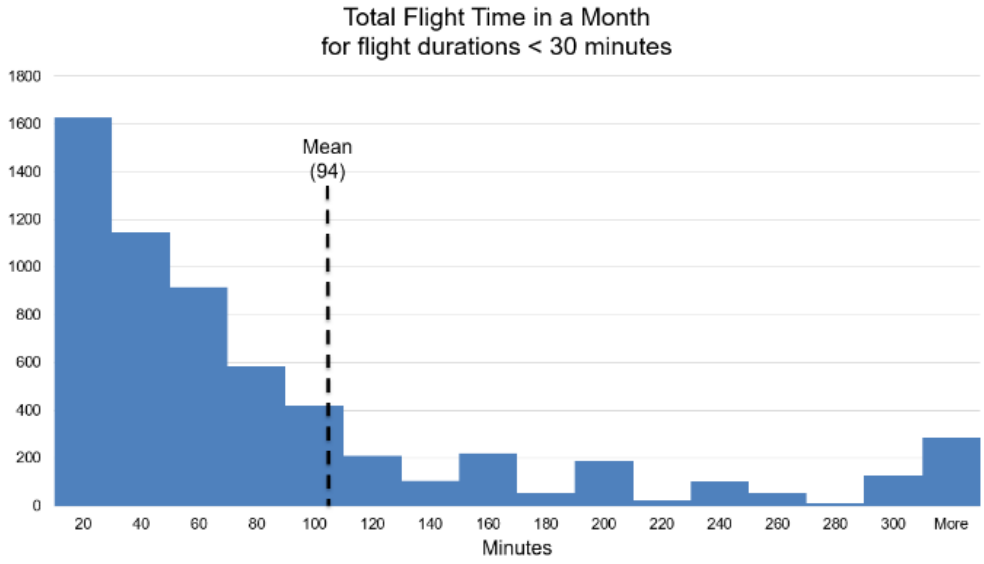


Recreational respondents tend to fly about 16 minutes per flight, on average. After adjusting for measurement error, we observe flight duration normally distributed around the mean of 15.6 minutes [see graph below].[16]

[15] Analysis of responses suggest that individuals who reported flying 30 minutes or more per flight misconstrued the scope of the questions. To reduce the measurement error, respondents with 30 minutes or more of flight time are removed from the sample.



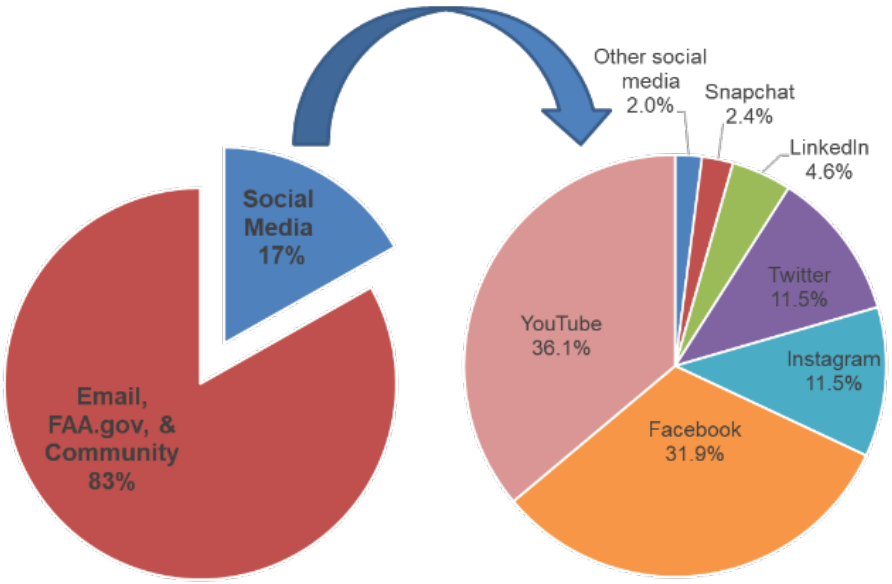
Respondents are estimated to fly, on average, 94 minutes per month [see graph below]. While most of the respondents log less flying time per month, between 20-40 minutes, quite a few respondents tally far more active flying time as well.



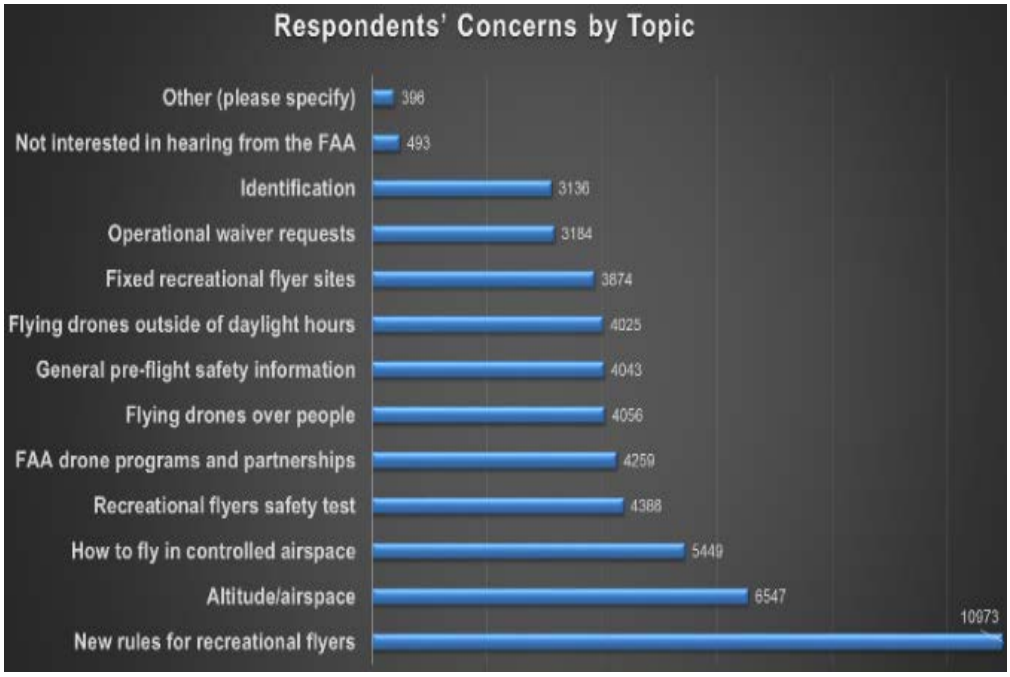
Generalizing the sampled individuals to all registrants, responses suggest that recreational sUAS operators log 1.5 million hours of flight time every month within the United States.

Turning our attention to communication preferences, respondents overwhelmingly receive communication from the FAA by email, with 74% of respondents reporting email among the sources of FAA information. The FAA website was a distant second at 28% of respondents. Only 17% of respondents reported some type of social media, with YouTube and Facebook as the preferred platforms. Only 6% of respondents reported receiving information about the FAA from community organizations. In the write-in section of the questionnaire, 3.4% of respondents reported preferring information by physical mail or mobile devices, either by text or app. The vast majority of respondents,

90%, reported finding information from the FAA helpful.



Overall, respondents were overwhelmingly interested in new rules for recreational flyers (73%). Operating in controlled airspace or in prohibited altitude/airspaces were the next most interesting topics, at 37% and 43% respectively. The remainder of the options garnered interest from 25% respondents, on average. A complete distribution of the responses on topics of their concerns is provided in the chart below.



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 (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. Following a temporary halt in registration due to an order from the U.S. Court of Appeals in Washington, D.C. in May, 2017, the registration requirement for all model aircraft was reinstated in December, 2017 with the National Defense Authorization Act (NDAA). Despite the temporary halt, registration pace continued beyond May, 2017. 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].

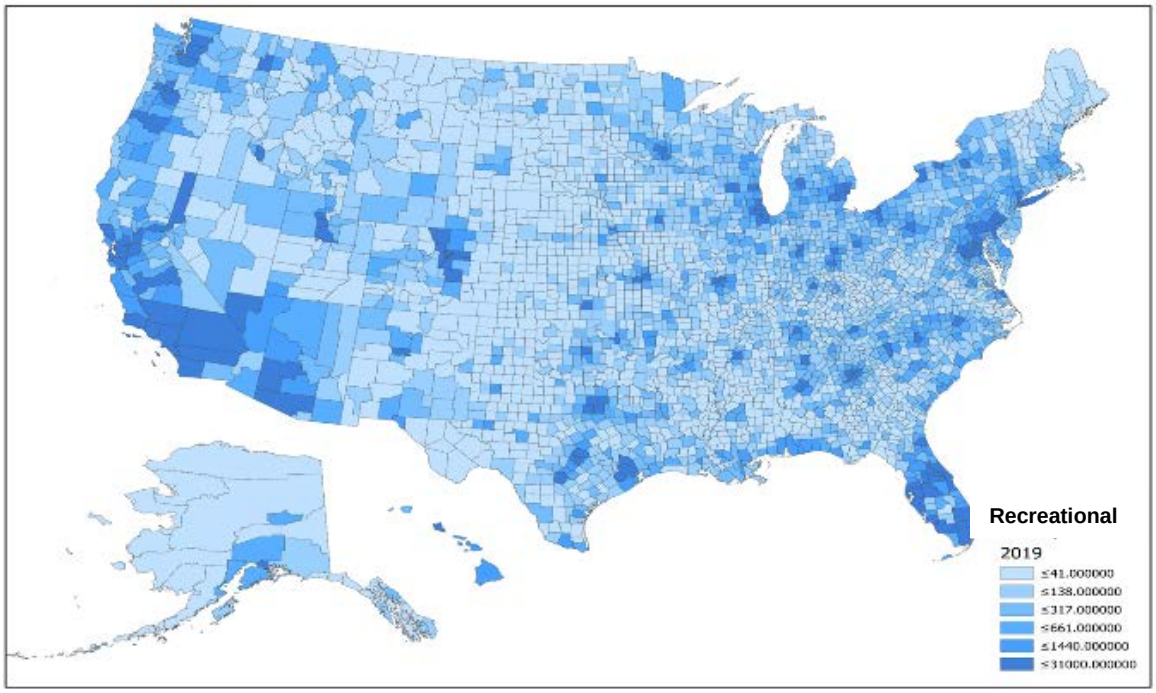
With the continuing registration, almost 990,000 recreational UAS owners had already registered with the FAA by December, 2019.[17] On average, owner registration stood at around 9,000 per month during January-December, 2019 with some expected peaks during the holiday seasons and summer.

[17] For our estimate and projections using registration database, applying to recreational, non-model or commercial and remote pilots, we use only those who are registered in the U.S. and the territories. Furthermore, we only use those registrants who are "active"; those whose registrations have been canceled or withdrawn are not part of the data we report in this document.

The pace of registration seems to have stabilized compared to last year in the same period; monthly owner registration during 2019 stands at around the same level as in 2018.

Recreational registration, and thus ownership of sUAS, is distributed throughout the country. Using the data as available in December 2019, a spatial distribution of ownership at a county level below demonstrates that sUAS continue to be distributed throughout the country with denser ownership mapping closely against the population centers of the country, as expected.[18]

[18] Registration data contains location of registrant by zip code. Registrants are mapped to counties by their reported zip code.



At present, the recreational ownership registration does not correspond one-to-one with aircraft in the system, the primary focus of the Agency. Unlike their commercial non-model counterparts, the registration rules for recreational operators do not require owners of recreational UAS to register each individual aircraft; only operators are registered. For each registration, therefore, one or more aircraft are possibly owned, with a few exceptions for no equipment ownership as well. 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 UAS fleet from gradual integration into the NAS. Finally, the Agency has engaged outside consults to aid forecasting efforts for both the recreational and commercial UAS fleet in this past year as well. We use all these resources to analyze and forecast both UAS types' activities in the U.S.

With around 990,000 recreational operators registered as of December 31, 2019, we estimate that there are around 1.32 million fleet distinctly identified as recreational aircraft. Comparing with industry sales and otherdata noted above, we conclude that recreational

aircraft is almost 34% higher than ownership registration[19].

A comparison of last year's data (2018) with this year's (2019) shows the annual growth rate to be approximately 6.4%. Such a growth rate is expected due to the introduction of drones as a recreational UAS, which is facilitated by falling equipment prices, improved technology such as built-in cameras and higher capability sensors, and relatively easy maneuvering. However, similar to all technologies including hobby items, (e.g., cell phones and video game consoles; and prior to that, video cameras, and video players), the trend in recreational UAS has been slowing and 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 as eagerness plateaus.

Given the trend in registration and market developments, we forecast that the recreational UAS market will saturate at around 1.5 million units. However, there is still some upside uncertainty due to further changes in technology including battery, facilitating regulatory environment, and the likely event of continued falling prices. This yields to some larger upside uncertainty in the forecast. In contrast, there is relatively less low-side uncertainty. Hence, we provide a forecast base (i.e., likely) with high and low scenarios, provided in the table below.

	Total Recreation/Model Fleet (Million sUAS Units)		
year	Low	Base	High
2019	1.32	1.32	1.32
2020	1.36	1.38	1.42
2021	1.37	1.42	1.49
2022	1.38	1.45	1.54
2023	1.39	1.47	1.57
2024	1.39	1.48	1.59

Last year, we forecasted that the recreational UAS sector would have around 1.314 million sUAS in 2019, a growth rate exceeding 5.5% from the year before (2018). Actual data

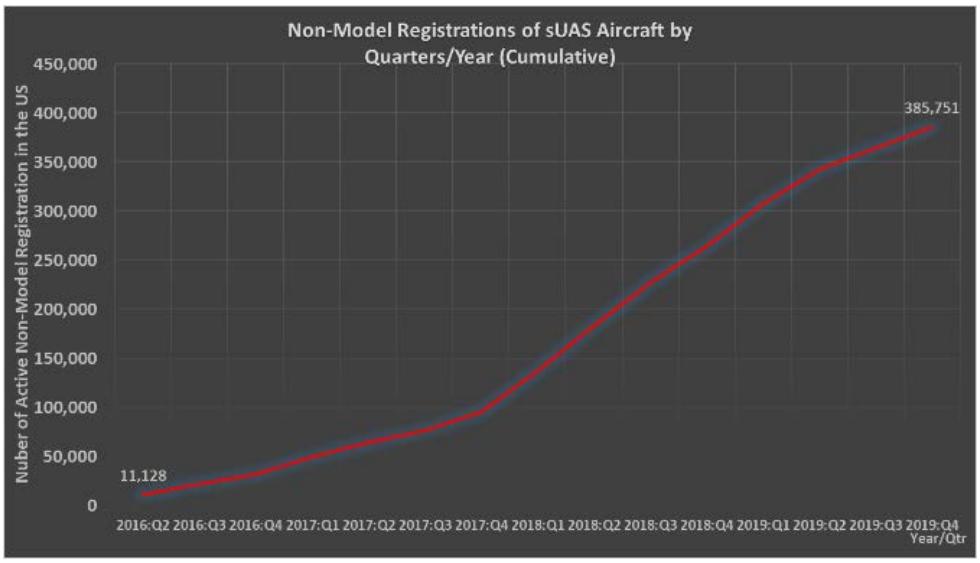
[19] This calculation involves taking into account retirement, redundancy, and loss of craft corresponding to ownership registration. As craft becomes sturdier and operators situationally aware, we expect this rate to change dynamically over time. Furthermore, with FAA regulations increasingly encouraging recreational drones to be registered, as opposed to ownership, registration would soon come to represent equipment like commercial counterpart.

came close to that projection with over 1.324 million aircraft already by the end of 2019. Thus, our forecast of recreational sUAS last year undershot by less than 1% (or, -0.78%) for 2019 (or 1.324 million actual aircraft vs 1.314 million aircraft that we projected last year).

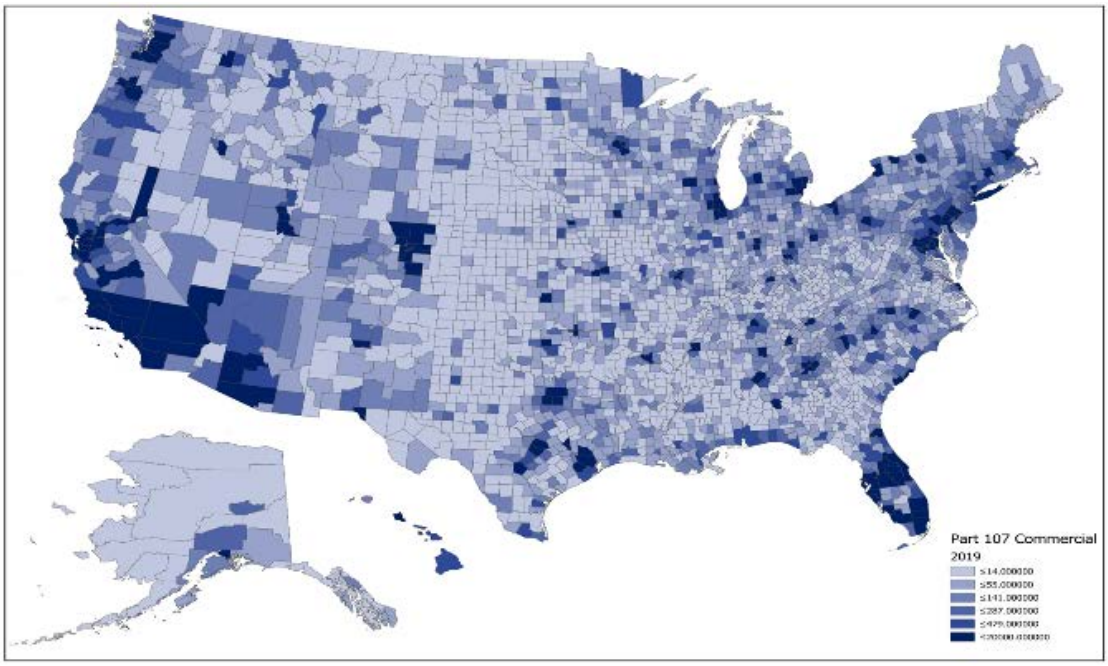
The FAA uses the trend observed in registrations, particularly over the past year; expert opinions collected in TRB annual workshops; review of available industry forecast; market/industry research; and a time-series model on registration trends fitted on monthly data. Using these, we forecast that the recreational UAS fleet will likely (i.e., base scenario) attain its peak over the next 5 years, from the present 1.32 million units to around 1.48 million units by 2024. The high scenario may reach as high as 1.59 million units with low-side scenario yielding around 1.39 million units over the next 5 years. As evident, 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 UAS 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 part 107 or commercial 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, 2019, more than 108,000 commercial operators registered their equipment. The pace of monthly registration, slightly above 10,000, is still relatively high but lower than the same period in 2018. It appears that the pace of registration is slowing down in comparison to 2018, but it is still over 2.5 times higher than the pace at which commercial UAS owners registered their craft during the earlier period (i.e., April 2016 – November 2017). While the pace of recreational registration ownership has slowed down considerably, the pace of registration remains accelerated for their commercial counterparts. By the end of 2019, there were more than 385,000 commercial UAS registered since the registration opened.



For each month the registration has been available, over 4,600 aircraft/month were registered until November, 2017. This pace accelerated to 14,600 registered per month during 2018. This past year (2019), average monthly registration stood at around 10,100. The commercial UAS sector is dynamic and appears to be at an inflexion point, demonstrating powerful stages of growth. Unlike the recreational UAS 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 clarity that part 107 has provided to the industry; e.g., proposed new rule changes. [See https://www.federalregister.gov/documents/2019/02/13/2019-00732/operation-of-small-unmanned-aircraft-systems-over-people for operations over people and at night without waivers and remote identification https://www.federalregister.gov/documents/2019/12/31/2019-28100/remote-identification-of-unmanned-aircraft-systems for remote identification NPRM]. Furthermore, given the possibilities for waivers, including 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 2019, 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 400,000 sUAS in 2019, a growth rate exceeding 44% over the year before (2018). Actual data came close to that projection with over 385,000 aircraft already registered by the end of 2019. Our forecast of commercial sUAS last year thus overshot by 4% for 2019 (or 385,450 actual aircraft vs 400,455 projected last year). Forecasting in a time of such monumental transition is indeed challenging, and the commercial UAS sector's fast growth is a demonstration of that fact. Nevertheless, our forecast errors for both recreation and commercial appear to be within the bounds of reasonableness.

	Total non-Model Fleet		
	(no. of '000 units)		
year	Low	Base	High
2019	385	385	385
2020	467	507	594
2021	535	633	830
2022	567	731	1031
2023	586	786	1136
2024	598	828	1197

Given the trend observed in the registrations, information from survey conducted in 2018, review of available industry forecasts/workshop and UAS Symposium, and internal research together with market/industry research, the FAA forecasts that the commercial UAS fleet by 2024 will likely (i.e., base scenario) be more than twice as large as the current number of commercial UAS[20]. 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 understood only a few years ago. Given the accelerated registration over the last year, the FAA now projects the commercial sUAS sector will have around 828,000 aircraft in 2024, the end of the 5-year period.

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 sUAS have a wide range of prices, below US $10,000 with an average unit price of approximately $2,500. The professional grade is typically priced above US $10,000 with an average unit price assumed to be around $25,000[21]. 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 UAS sector with a market share approaching 94%. 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 2024, FAA projects this sub-sector will have approximately 85% of the overall commercial sUAS sector.

Starting from a low base of approximately 25,000 aircraft in 2019, the professional

[20] Last year, the ratio of end-year of forecast to base year forecast was 3-times; i.e., we forecasted end-year to be 3 times the base year's (2018) numbers in 5-year.

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

grade commercial sUAS sub-sector stands to expand rapidly over time, especially as newer and more sophisticated uses are identified, designed, and operationally planned and flown. If, for example, professional grade sUAS meet feasibility criteria of operations, safety, regulations, and satisfy economics and business principles and enters into the logistics chain via small package delivery, the growth in this sector will likely be phenomenal. This growth trajectory could be even further enhanced by expanding operations, e.g., the Low Altitude Authorization and Notification Capability (LAANC) system[22], which began authorization in May, 2018. LAANC is designed to allow considerable flexibility in sUAS operations and to facilitate sUAS use of 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.

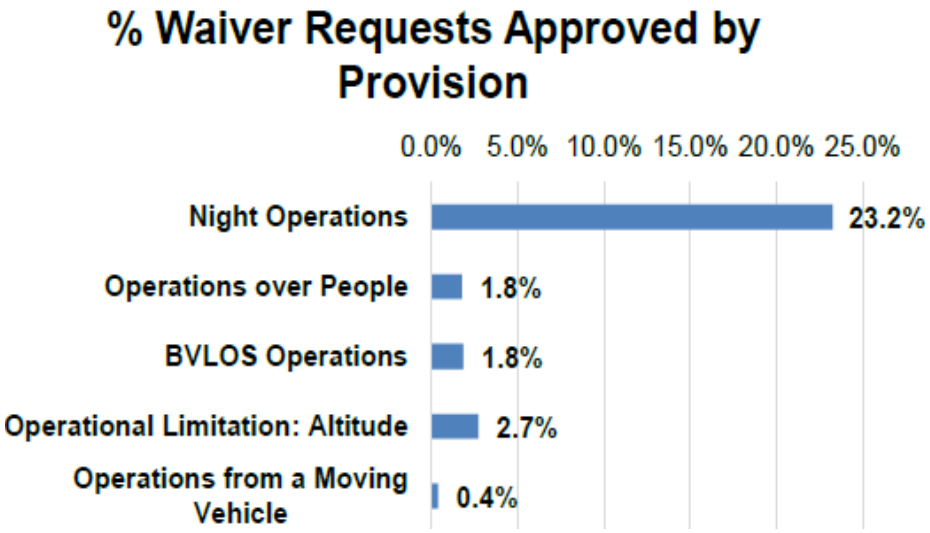
Unlike its recreational UAS counterpart, it is extremely difficult to put a floor on the growth of the commercial UAS sector due to its composition (i.e., consumer vs professional grades) and the varying business opportunities and growth paths. As commercial UAS become operationally more efficient and safe, battery life expands, and regulatory constraints are gradually relaxed, 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 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. 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 17% and 35%, respectively. Average annual growth rate corresponding to the low scenario, on the other hand, is around 9%.

Commercial sUAS are presently 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 participants' activities under the Integration Pilot Program (IPP). FAA awarded 10 communities, among a pool of 149 applicants, [https://www.faa.gov/uas/pro-

[22] 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, 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.

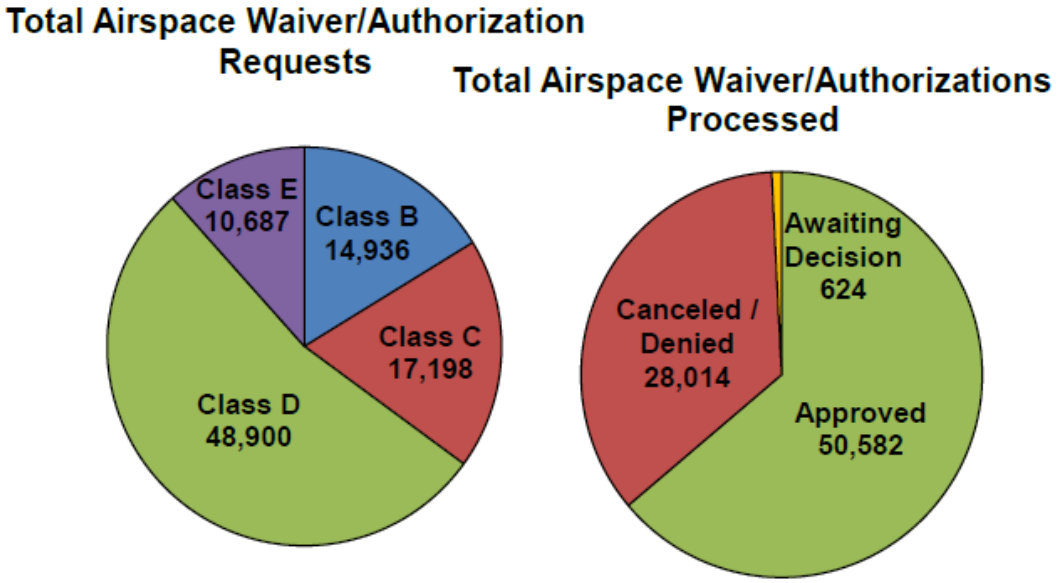
grams_partnerships/integration_pilot_program/lead_participants/] membership in the IPP in May, 2018. IPP applications and preliminary data indicate that awardees overwhelmingly pursuing numerous private business and public interest activities.

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, 2019 is shown in the chart below

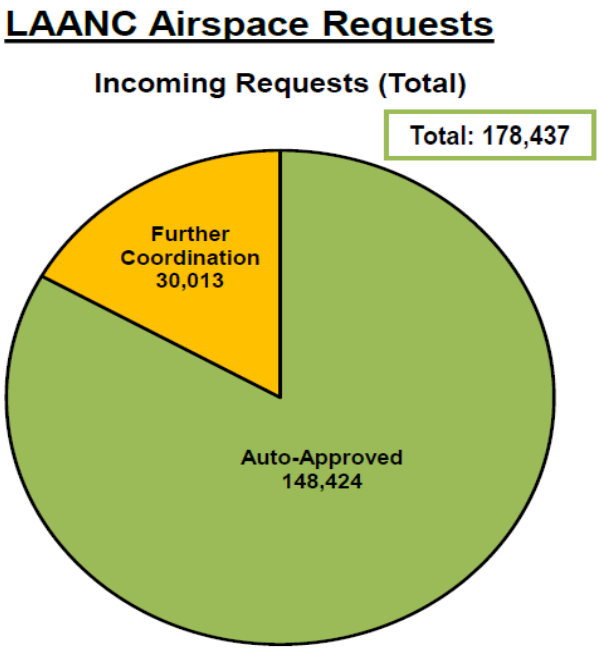


Beyond the daytime operation that is presently allowed under existing part 107 rules, expanding applications further requires waivers, to a large extent, for night operations as distinct from daylight operations (over 1 in 5 waivers); there are also limitations on altitude, for which waiver requests are made at a rate of 2.7%. Many of these waivers are combined, and thus total waivers (i.e., full + partial) granted (over 3,500 in December 2019) exceed 100%. The Agency issues these waivers to facilitate business activities by sUAS while preparing for the next round of regulations that will routinely allow the present waiver requirements. [See https://www.federalregister.gov/documents/2019/02/13/2019-00732/operation-of-small-unmanned-aircraft-systems-over-people for current NPRM on operations of small unmanned aircraft over people in certain conditions, and operations of small UAS at night without obtaining a waiver]. Analysis of these waiver applications allows us to understand the industry trends, one of many metrics essential for understanding and projecting the trajectory, course corrections, and growth trends of the sector.

Almost 50% of airspace authorizations and waivers were approved for the controlled airspaces at the end of December, 2019. 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, 2018, and covers all airports presently. It has provided, so far, over 148,000 auto-approvals for airspace access requests [see below]; over 100,000 more since this time last year, while sending over 30,000 for further coordination (an increase of over 23,000 from last year). 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.



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 2019, 162,185 RP certifications have been issued[23].

Part 107 RP 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 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 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

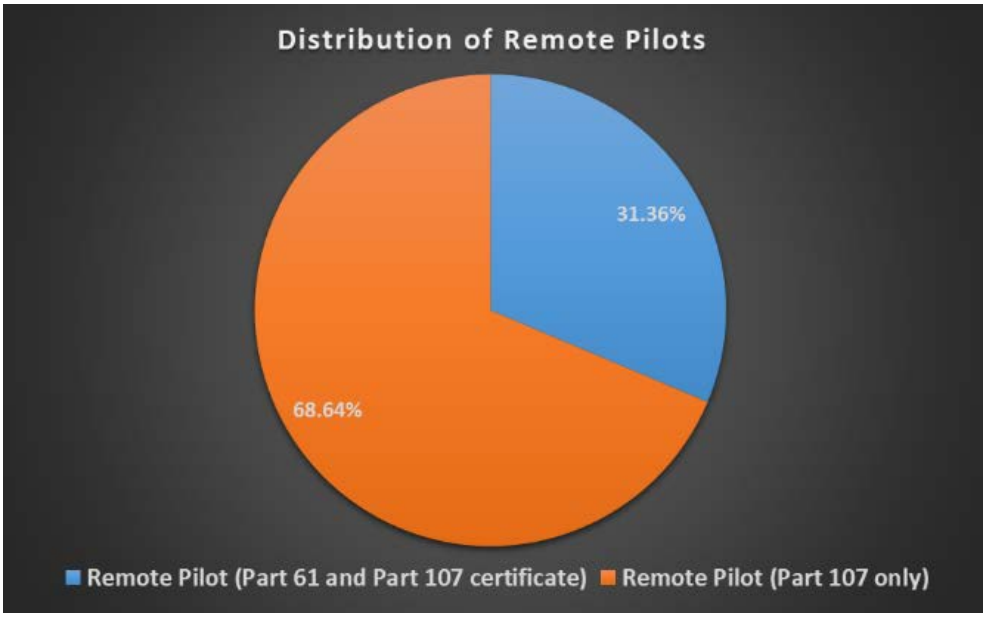
[23] In our accounting of RPs, we take pilots who passed the initial knowledge test (or part 107) plus current manned pilots who took online training in lieu of the knowledge test (or part 61).

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].

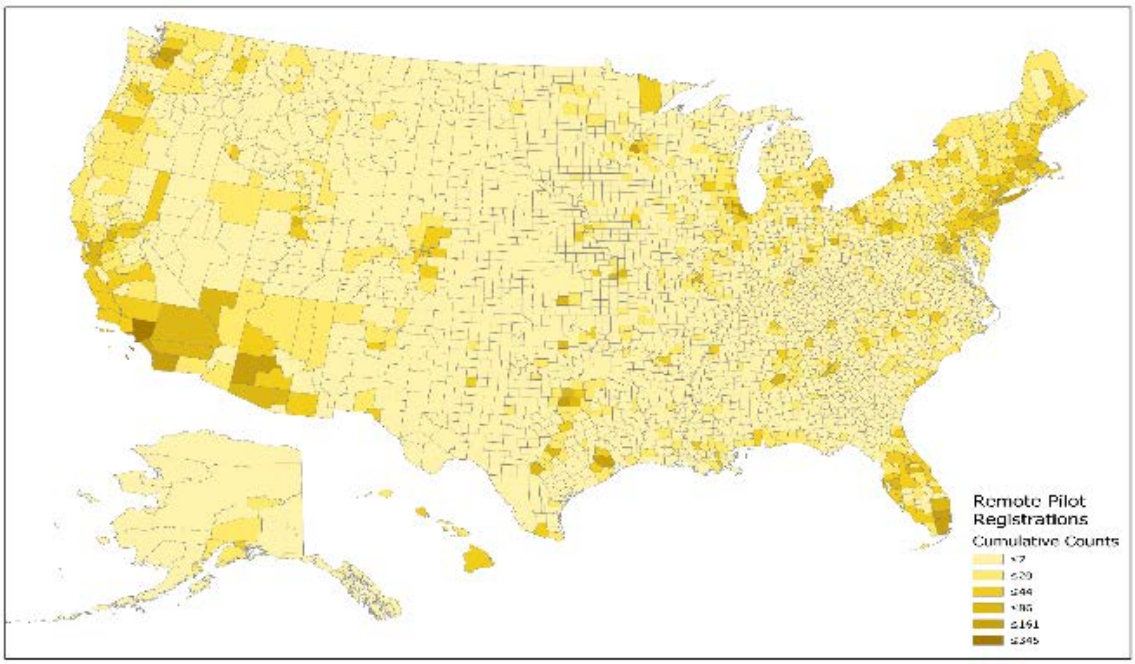
Following the process above, the FAA classifies RPs into two categories:

- 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.



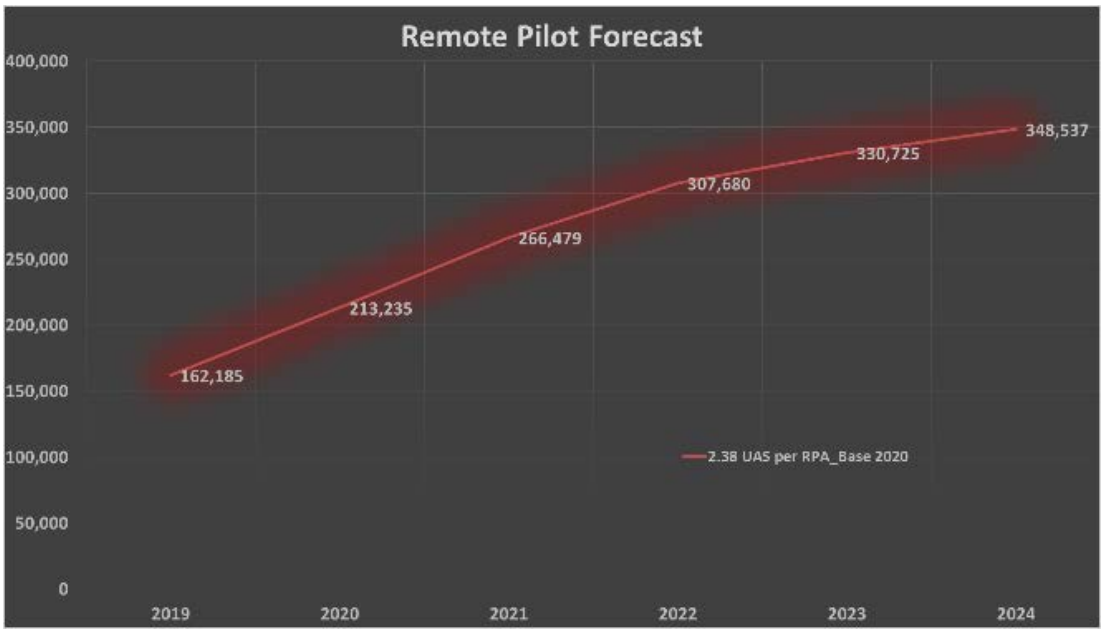
Over 2/3 of the RPs are part 107 RPs only. Over 90% of those who took the exam passed and obtained RP certification. A cumulative density distribution of remote pilots at a county level is provided in the map below.[24]



The RP forecast 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 forecast of fleet. Given the trends in registration and our forecast of the commercial UAS fleet, the FAA assumes that one RP is likely to handle 2.38 units of commercial sUAS.

Using these assumptions and combined with the base scenario of commercial sUAS forecast, the FAA project RPs in the graph below. Last year, the FAA projected RPs to be around 167,500 by the end of 2019; which fell short by 5,000.

[24] Remote pilot data contains location by zip code. Remote pilots are mapped to counties by their reported zip code.



Given the actual numbers at the end of 2019, the FAA made the adjustments to RPs per commercial sUAS (2.38), thus lowering it slightly from last year's, 2.4. Despite this adjustment, RPs are set to experience tremendous growth following the growth trends of the commercial sUAS sector. Starting from the base of 162,185 RPs in 2019, commercial activities may require almost 350,000 RPs in 5 years, more than two-fold increase, providing tremendous opportunities for growth in employment associated with commercial activities of UAS. Potential for RPs may enhance even more if larger UAS are used in commercial activities and urban air mobility become a reality in the near future.

Larger UAS

According to FAA rules, UAS weighing 55 pounds or greater must be registered using the existing aircraft registration process (see https://faadronezone.faa.gov/#/). 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. In order to calculate larger UAS (lUAS) in the NAS, we employ multitudes of data from various sources: the Certificate of Authorization (COA) Online system and its successor CAPS or COA Application Processing System; MITRE's Threaded Track infusing data from different sources (see https://www.mitre.org/publications/technical-papers/threaded-track-geospatial-data-fusion-for-aircraft-flight-trajectories); FAA's Performance Data Analysis and Reporting Systems or PDARS (see https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/perf_analysis/perf_tools/ for more details); and Notices to Airmen (NOTAM) (See https://notams.aim.faa.gov/#Applications).

Combining these data sources, MITRE estimates 206 lUAS operation in the NAS in 2019. This is a 20% increase from the 172 lUAS operating in 2018. Most of the lUAS introduced in 2019 are operated by government agencies, with the DoD claiming the

bulk of the aircraft. Military lUAS have begun to increase after several years of declining operates in the NAS, suggesting the military fleet is expanding. The other source of lUAS growth is from the increased use of lUAS in commercial applications. Most of the commercial lUAS are operated in public-private partnerships, but these pilot programs are paving the way to widespread commercial use of lUAS in the future.

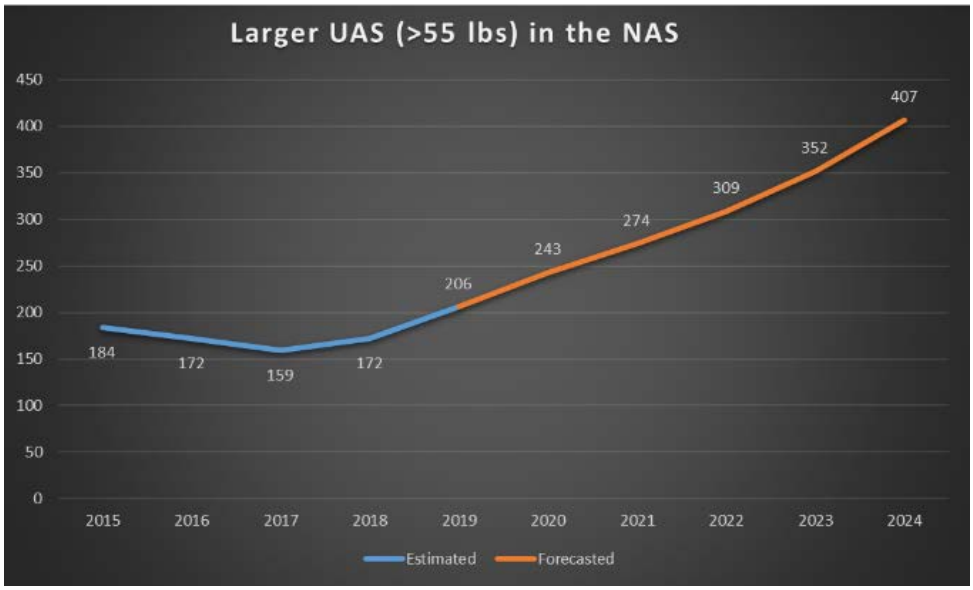
Since lUAS cannot operate under part 107, commercial operators must obtain an exemption under section 44807 [see https://www.faa.gov/uas/advanced_operations/section_333/how_to_file_a_petition/ for more details]. With the exemption, commercial operators are allowed to register their lUAS as aircraft under part 47 and operate them under part 91. As such, the number of exemptions granted for UAS larger than 55 lbs is the lower bound for the number of commercial lUAS in operation. In 2017, five new exemptions for lUAS were granted while six new lUAS were registered under part 47, and 22 new exemptions were issued with 22 lUAS added to the register in the following year. As such, the increase in the number of exemptions heralds an increase in the number of lUAS operating in the NAS.

Exempts are expected to increase over the next couple of years. In 2019, 19 companies were issued new FAA exemptions for commercial lUAS, the majority for agricultural purposes. For 2020, seven companies with federal-agency sponsorship are expected to seek exemptions for lUAS as well as several other non-sponsored companies. This suggests an upward trend in the number of exemption and hints at increasing demand for commercial lUAS.

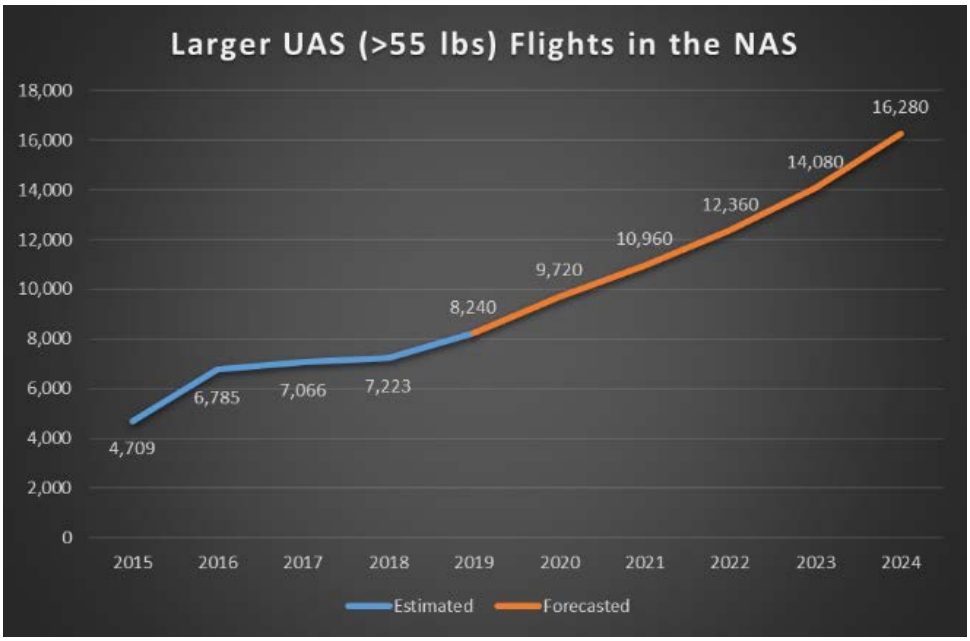
Larger UAS (>55 lbs) forecast in the NAS			
Year	Exemptions	Larger UAS	No. of Flights
2015	0	184	4,709
2016	0	172	6,785
2017	5	159	7,066
2018	22	172	7,223
2019	19	206	8,240
2020	21	243	9,720
2021	25	274	10,960
2022	34	309	12,360
2023	48	352	14,080
2024	67	407	16,280

Combining the baseline growth from the military and civilian agencies and projections of commercial exemptions under 44807, lUAS are expected to increase by 37 aircraft in 2020 due to more commercial applications and an expansion of military and civilian aircraft. As commercial use accelerates and military investment stabilizes over the next half decade, lUAS are projected to increase to 407 aircraft by 2024. However, the sunset of Section 44807 in September, 2023 could

drastically flatten and reduce number of lUAS after 2024 if an alternative is unavailable.



Correspondingly, the number of lUAS flights is expected to increase from the estimated 7,360 in 2019 to 16,280 by 2024, but a considerable number of the additional flights are likely for agricultural applications, operating well below controlled airspace.



Urban Air Mobility

In Sept 2017, NASA launched a study to assess the segment of autonomous vehicles broadly called Urban Air Mobility (or UAM). UAM is defined as “a safe and efficient system for air passenger and cargo transportation within an urban area, inclusive of small

package delivery and other urban Unmanned Aircraft Systems (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) UAM technology presents considerable opportunity for economic growth over the coming decades. Markets for UAM services, such as delivering packages by drone or large cargo or unmanned passenger shuttles, have a huge potential both in the United States and globally. However, UAM services are likely to face stiff competition from technological advances in industries with close substitutes, such as ground transportation. In addition, the high costs of urban infrastructure to facilitate these activities could slow down UAM adoption.

Package or larger cargo delivery, on the other hand, is the UAM service that is most likely to see economic growth in the next decade. By 2030 "last mile package delivery" could be profitable at a price point of $4.20 per delivery and may result in around 500 million deliveries annually with a fleet of 40,000.[25]

Airport shuttles and other fixed-route passenger services are the UAM passenger services most likely to gain economic traction in the coming decade. Under some assumptions, a highly-automated "air metro" could be profitable by 2028 and by 2030, it may result in 750 million annual passenger trips in 15 metro areas or 137 thousand passenger trips/day/area. Under more conservative assumptions, UAM market may yield $2.5 billion in passenger transport market revenue with around 8.2 thousand passenger trips/day/area. While air ambulance model may not be profitable, it may have high impact on public good [see https://www.nasa.gov/uam-studies-reports/].

Some others estimate the UAM passenger industry to have 23,000 aircraft with 740 million enplanements per year at a price of around $30 per trip by 2030.[26] However, 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 UAM market development. As such, estimates by KMPG only predict 60.4 million enplanements by 2030 and a much smaller industry size.[27] Similarly, Roland Berger estimates a fleet of only 12,000 passenger UAS by 2030.[28] However, given the current safety, technology, and urban environment challenges, even these projections may likely to be somewhat optimistic within the timeframe.

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

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

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

[28] 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).

Passenger services promise larger markets for UAM services, but safety realities and technology may limit UAM's wide penetration into the passenger-services market. On the other hand, the UAM passenger industry is likely to be conspicuous due to an inflow of venture capital and experimental services exploring market potentials.

As the sector grows and new initiatives are undertaken, the Agency is keeping a keen eye on understanding the exploratory trajectory and growth trends in UAM. As more information becomes available, the FAA will likely provide emerging trends and forecast in the near future.