Unmanned Aircraft Systems

From its infancy, just a few years ago, unmanned aircraft systems (UAS) have been experiencing robust growth in the United States and throughout the world. A UAS is an unmanned aircraft and its associated communication links and control components required for the safe and efficient operation of the unmanned aircraft in the national airspace system (NAS). While the introduction of UAS into the NAS has opened up numerous possibilities, it has also created unique operational challenges. Despite these challenges, the UAS sector holds enormous potential, with commercial applications ranging from aerial photography to package delivery.

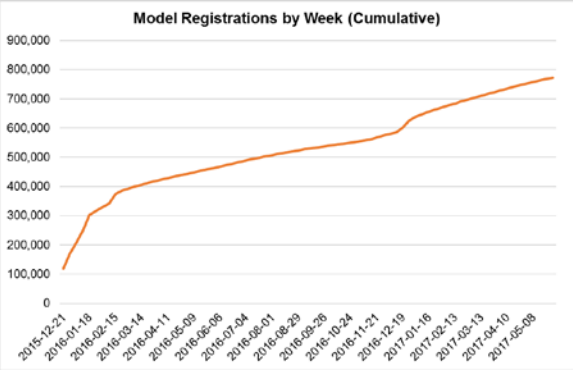
This section covers trends across the broad landscape of the established and emerging UAS industry, from model to non-model aircraft[6] . Using these trends and insights from industry, the FAA has produced a number of forecasts. The forecasts reported in this section are driven primarily by the assumption of the continuing evolution of the regulatory environment, the commercial ingenuity of manufacturers and operators, and underlying demand, including business models. These drivers will continue to advance safe integration of UAS into the NAS.

Trends in UAS and Forecast

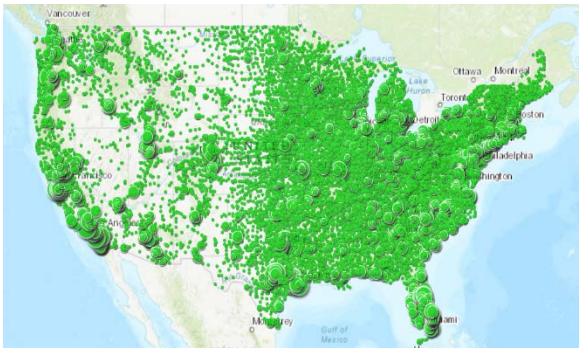
FAA's online registration system went into effect on Dec. 21, 2015. This required all UAS weighing more than 0.55 pounds (250 grams) and less than 55 pounds to be registered using a new on-line system (https://www.faa.gov/uas/getting_started/registration/) or using the existing (paper-based) aircraft registration process. However, the U.S. Court of Appeals issued an order suspending the registration requirement for model aircraft owners on May 19, 2017. On December 12, 2017, the President signed the 2018 National Defense Authorization Act (NDAA), which reinstated the registration requirement for all model aircraft.

By the end of May 2017, more than 772,000 owners had already registered with the FAA. While mandatory registration was in effect until the last week of May 2017, the trend was one of slowing growth over time. On average, weekly registration ranged from 4,000-5,000 from January-May, 2017, with some expected peaks during the holiday season. Following the Court Order, the online registry continued to accept voluntary registrations from modelers. However, the registration data from the second half of 2017 may not reflect an accurate trend for model aircraft growth.

[6] These are also called, interchangeably, hobby and non-hobby UAS, respectively. In previous notes including other documents of the Agency, these terms are often interchanged.



Model registration and thus ownership of small model UAS is distributed across the country. A spatial distribution of ownership demonstrates that sUAS are distributed throughout the country with denser ownership mapping closely against the population centers of the country.



Registration does not translate to aircraft in the system, the primary focus of the Agency. Unlike registration for non-model aircraft, the registration rule does not require modelers to register each individual aircraft; owners may register once and apply their registration number to multiple model aircraft. For each registration, therefore, one or more aircraft are possibly owned (with few exceptions of no equipment being owned as well).

Under the sponsorship of the UAS Implementation Plan, the FAA has launched various research activities to understand the possible magnitude of the UAS sector, implications on the spectrum of aircraft that may be used for model flying, and the safety implications of the gradual integration of the UAS fleet into the NAS. The Agency has also engaged outside consulting firms to aid forecasting efforts for both the model and non-model UAS fleet.

Prior to undertaking the forecast, the first task was to extrapolate the trends of model ownership registration beyond May 2017 for the entire year, using data from earlier years and industry information. This introduces considerable uncertainty in the forecast, particularly for model aircraft. Thus, the FAA continues to recognize, as in earlier years, that uncertainty abounds in projections for both the model and non-model UAS fleet. Hence, we provide a forecast base (i.e. likely) with high (or optimistic) and low ranges in the following table for the model UAS fleet.

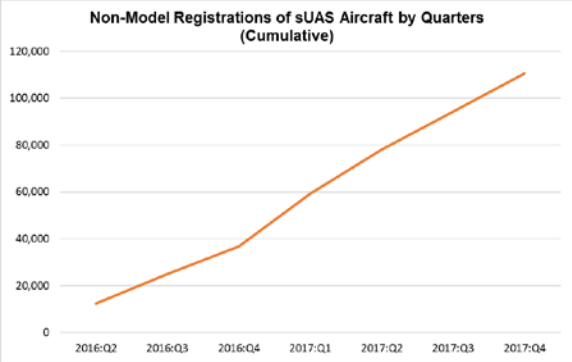
With over 873,000 modelers registered as of December 31, 2017 (extrapolated from June-December), we project that there are around 1.1 million sUAS identified distinctly as model aircraft. In contrast to last year's projection of 1.1 million units, the actual number of model aircraft was around 788,570 for 2016 – 28% lower than what we projected. A comparison of last year's data with this year's (2017) shows the compound annual growth rate to be around 40%. This is still a substantial growth rate, as anticipated from the introduction of drones as a hobby, facilitated by falling equipment prices, improved technology such as built-in cameras, and the relative ease of maneuvering. However, the trend is likely to slow as the pace of falling prices slow and early adopters begin to experience limits to their experiments. Given the trend observed in the number of registrations, expert opinions collected in Transportation Research Board (TRB) annual workshops, re-

view of available industry forecasts, and market/industry research, we forecast that the model fleet will likely (i.e. base scenario) more than double in size over the next 5 years, from the present 1.1 million units to over 2.4 million units. The high/optimistic scenario suggests this growth may be as high as 3.17 million units, while the low scenario shows it could be as low as 1.96 million units. The growth rates underlying these numbers are fairly steady in the initial years but more modest in the last 2 years. The gradual market saturation that is projected in 5 years and beyond in the model aircraft fleet parallels other consumer technology products such as cell phones and video game-consoles, and prior to that, video cameras and video players.

	Total Model Fleet (Million sUAS Units)		
year	Low	Base	High
2017	1.10	1.10	1.10
2018	1.50	1.60	1.73
2019	1.76	2.00	2.35
2020	1.87	2.20	2.73
2021	1.92	2.30	2.94
2022	1.96	2.40	3.17

Commercial UAS Forecast

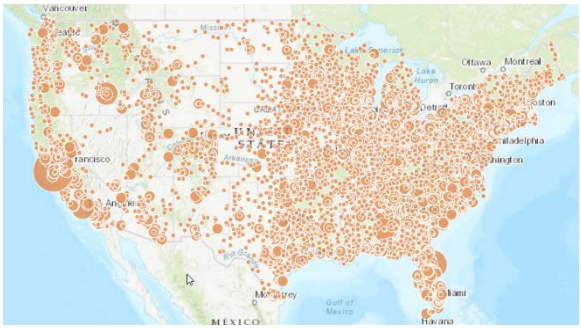
The online registration system for the non-model fleet went into effect on April 1, 2016. Unlike the rules for model ownership, non-model owners must register each individual UAS. Since the launch of on-line registration, more than 110,000 commercial operators had registered their equipment by the end of 2017. Information contained here shows the trend in the total fleet size since the time when registration began in the 2nd quarter of 2016.



For each week the registration has been available, over 1,000 aircraft have been registered. As in the case of model UAS ownership, non-model UAS are distributed across

the country. A spatial distribution of unit registration (using data for October 2017) demonstrates that non-model UAS are distributed throughout the country, with denser activities correlating closely with the economic or commercial activities of the country.

The non-model sector is primarily commercial in nature. It is very dynamic and appears to be at an early stage of growth. Unlike the model sector, we anticipate that the growth rate in this sector will continue to accelerate over the next few years. Additional commercial uses will likely result from both the clarity that Part 107 has provided and the possibilities for waivers, which will likely facilitate further growth in the sector.



Last year, we forecasted that the non-model sector would comprise approximately 108,000 aircraft in 2017, a growth rate exceeding 150% from the base of 42,000 in 2016. Actual data indicate there were 110,604 UAS registered at the end of 2017. Considering the trend observed in the registrations, expert opinions provided during the TRB workshops, review of available industry forecasts, internal research, and market/industry research, we project that the non-model fleet by 2022 will likely (i.e. base scenario) be four times larger than the current number of non-model aircraft. As the present base (i.e. cumulative total) gets larger, we anticipate the growth rate of the sector will slow down over time as well.

The forecast of non-model UAS does not fundamentally change from the growth path laid out last year. Similar to last year, we project the non-model sUAS sector will be over 450,000 in 2022.

We divide the non-model sector into two types of UAS aircraft: consumer grade and professional grade. The consumer grade non-model aircraft have a wide price range, below US $10,000 with an average unit price of around $2,500. The professional grade is typically priced above $10,000, with a unit price assumed to be around $25,000. Currently, the consumer grade dominates the non-model sector, with a market share approaching 98%. However, as the sector matures and the industry begins to consolidate, the share of consumer grade non-model aircraft is likely to decline but remain dominant. By 2022, FAA projects this sub-sector will have less than a 90% share of the overall consumer grade non-model UAS sector.

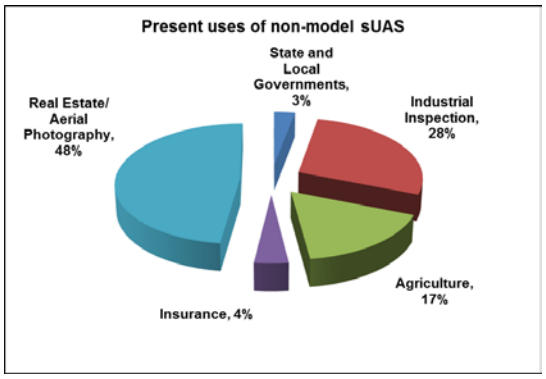
Starting from a low base of around 3,000 aircraft in 2017, professional grade non-model UAS stand to expand rapidly over time, especially as newer and more sophisticated uses are identified, designed, and planned. If, for example, professional grade UAS meet feasibility criteria of operations, safety, regulations, and economics/business, and they enter into the logistics chain via delivery of small packages, the growth in this sector will likely be phenomenal. In a similar vein, the Low Altitude Authorization and Notification

Capability (LAANC)[7], which began testing in 2017 and is planned to be rolled out nationally over this year, is designed to allow considerable flexibility in UAS operations and facilitate non-modelers' use of the NAS. While most of the near-term growth in non-model UAS will still come from operations with consumer grade UAS (over 90%), we anticipate the remainder will come from professional grade non-model UAS.

Unlike the model counterpart, it is extremely difficult to put a lower bound on the growth of the non-model sector due to its composition (i.e. consumer vs. professional grades) and the varying business opportunities and growth paths. As non-model aircraft become operationally more efficient and safe, battery life expands, and regulatory constraints are reduced, new business models will begin to develop, thus enhancing robust supply-side responses. These responses, in turn, will pull demand forces (e.g. consumer response to receiving commercial packages, routine blood delivery to hospitals, etc.) that are presently latent. As a result, we provide a likely or base scenario together with the enormous potential embodied in the "high" scenario, representing cumulative annual growth rates of 33% and 46%, respectively.

	Total non-Model Fleet (no. of units)	
year	Base	High
2017	110,604	110,604
2018	158,900	168,339
2019	229,400	268,937
2020	312,100	410,862
2021	407,400	604,550
2022	451,800	717,895

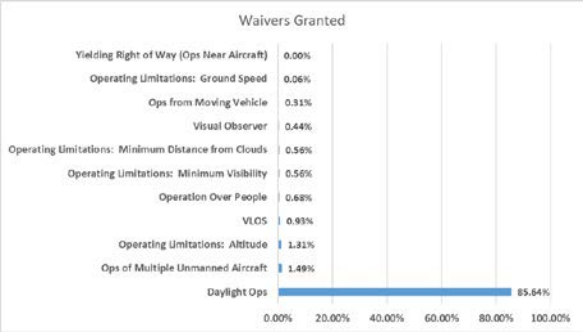
Non-model UAS are presently used for numerous purposes. A review of market analyses and industry information reveals their present uses (following chart) have not changed much from last year:



Non-model UAS are primarily used for aerial imaging and data collection, including real estate photography (48%), industrial and utility inspection (28%), and agricultural applications (17%), including crop inspection. Increasingly, state and local governments are using UAS for emergency services, including search and rescue operations, and presently employ around 3% of all non-model UAS. As the sector grows, there will be many more non-model UAS in use.

[7] Through LAANC, the FAA will grant real-time authorizations for operations complying with Part 107 via speeding up processing time (i.e., real-time) of the authorization requests. It is likely to reduce any distractions of controllers at the Towers.

One way of identifying early trends of non-model UAS uses is to analyze the waiver applications granted to non-model UAS operators. Both the magnitude and relative composition of waiver types may indicate the direction of the non-model UAS sector as a whole. A breakdown of the waiver requests granted is shown in the chart below:



Beyond what is presently allowed under Part 107, expanding non-model applications requires waivers for night operations (86% of all waivers granted), operation of multiple unmanned aircraft by one pilot (1.5%), and operations above current altitude limits (1.3%). Many of these waivers include combinations of multiple waived provisions, and hence, totaling waivers granted by provision (more than 1,600 in December 2017) exceeds 100%. The Agency issues these waivers to facilitate expanded commercial activities by non-model UAS on a case-by-case basis, while it develops additional regulations to enable more advanced operations on a routine basis. 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.

Finally, almost 13,000 airspace authorizations and waivers were approved for UAS operations in controlled airspaces by the end of December 2017. While over half of them were for operation in class D airspace (i.e., smaller airports with control towers), waivers for operation in other classes were also requested and approved.

Total Approvals	Auths	Waivers	Total
Class B	1,823	18	1,841
Class C	2,715	49	2,764
Class D	6,905	97	7,002
Class E	1,351	22	1,373
TOTAL	12,794	186	12,980

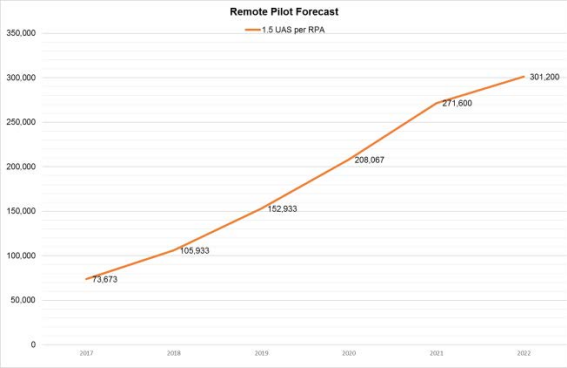
Large UAS

According to FAA rules, UAS weighing more than 55 pounds must be registered using the existing aircraft registration process (14 CFR part 47). Many of these aircraft are operated within the NAS by federal agencies, state and local governments, and national research organizations. While many of these organizations require certificates of waiver or authorization (COAs) to fly, others have their own procedures for authorizations, e.g. Military, Customs and Border Patrol (CBP), etc. While the FAA has a great deal of experience enabling operations with this class of UAS within the NAS, we do not have the equivalent level of understanding of the fleet numbers and trends in the growth of these types of UAS. Further examination and research may lead us to better identify trends and eventually develop a forecast in the future.

Remote Pilot Forecast

An important final metric in non-model sUAS is the trend in remote pilot certifications (RPCs). RPCs are issued in accordance with part 107 and are used primarily to facilitate non-model sUAS flights for commercial activities. As of December 2017, more than

73,000 RPCs were issued. Over 90% of individuals who took the required aeronautical knowledge exam passed and obtained an RPC. The RPC forecasts presented are based on two data sources: (a) trends in RPCs issued; and (b) trends in non-model sUAS registration and fleet forecasts. For projecting RPCs, we assume that one pilot is likely to handle 1.5 units of non-model sUAS.



Combining these assumptions with the base scenario of non-model sUAS forecast, we project RPCs in the above graph. As evident, RPCs are set to experience tremendous growth following the growth trends of the non-model sUAS sector. Starting from the base of 73,673 RPCs in 2017, non-model activities may require over 300,000 new remote pilots in 5 years, providing tremendous opportunities for growth in employment associated with commercial activities of the UAS.