ALPA WHITE PAPER

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Remotely Piloted Aircraft Systems

Challenges for Safe Integration into Civil Airspace

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Background

The history of interest in and use of unmanned aircraft, typically known as remotely piloted aircraft systems (RPAS), unmanned aircraft systems (UAS), or drones, exceeds 50 years. Until relatively recently, these aircraft were either prohibitively expensive, limiting their use to government and research organizations, or of relatively low performance, minimizing both their utility and the likelihood of interaction with other airspace users. In the past decade, technological advances have produced increases in performance and decreases in cost that in turn led to unprecedented interest in and development of UAS/RPAS. The access to relatively cheap, high-performance platforms has led to rapid increases in applications for both military and civil use. In addition, the low cost and relative ease with which a novice can operate small UAS has fueled an exploding hobby market. As a result of provisions in the 2012 Federal Aviation Administration (FAA) Reauthorization Act, commercial use of small UAS (under 55 lbs.) is being approved by the FAA in some circumstances and with limitations. In Canada, exemptions have been created to permit nonrecreational use of UAS weighing less than 55 lbs. without requiring an operating certificate when certain conditions are met. As well, a notice of proposed amendment was released in 2015 to set the stage for UAS regulations in Canada.

That same FAA legislation contained several key provisions that bear directly on the complexity of safely integrating UAS into airspace used by other aircraft. One such provision was a prohibition on the promulgation of any regulation covering the operation of "model aircraft," provided such aircraft are operated within a set of broadly defined guidelines. Another section of the legislation, by some interpretations, directed "integration" of UAS in the U.S. airspace by September 2015, a deadline which has now passed. However, exactly what constituted "integration" in that context was never explicitly defined. Canada is facing similar pressure, dating back as far as 2011 when an agreement was signed between the U.S. and Canadian governments (*http://actionplan.gc.ca/sites/eap/files/japlan_eng.pdf*) to foster cooperation to align our UAS regulatory frameworks to promote increasing use of UAS in both countries. As pressure mounts to expedite integration of RPAS into public airspace, efforts to develop the body of applicable regulations in both the United States and Canada are incomplete.

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In early 2015, the FAA released a notice of proposed rulemaking for small UAS (sUAS) as the first attempt by the FAA to propose regulations for the commercial use of those aircraft. It is ALPA's understanding that the congressional prohibition on regulating model aircraft had a direct impact on the scope of the FAA's 2015 proposed rule. Even then, the proposal drew over 4,000 comments from the public. The final rule will not likely be released until sometime in 2016, and as of this writing it remains to be seen to what extent the final rule will mirror the proposal. Also in 2015, Transport Canada published a notice of proposed amendment in its own effort to establish a regulatory framework for sUAS, including a desire to leave recreational use of UAS weighing less than 35 kg in their current self-regulation state but requiring recreational users to join a nationally recognized model aircraft association. In general, the existing experience with operation of UAS/RPAS, whether for recreational or commercial use, as well as ongoing attempts to develop a body of regulations and standards for their operation, has revealed many safety issues that need to be addressed to preserve the safety of operations in the airspace, especially that used by other aircraft.

ALPA has consistently taken the position that the efficient development of RPAS has many benefits and should be supported. However, ALPA has also consistently maintained that for these systems to be integrated into airspace already being used by aircraft with people on board, safety must be the single determinant of when that integration is achievable. Introduction of this new technology, however valuable in isolation, cannot be allowed to negatively impact the superb safety record that has become synonymous with commercial aviation.

Scope and Terminology

As noted above, aircraft being operated without an on-board pilot are referred to differently in various contexts and by various authors and spokespersons. The reference sometimes includes just the aircraft, as in "unmanned aircraft," "unmanned air vehicle," or "remotely piloted aircraft," and other times includes "system" in the label, acknowledging that the aircraft itself is part of a larger group of components that must all be present and working for flight (e.g., the external control station, analogous to the cockpit of a conventional aircraft). The inaccurate but widely used term "drone" is also frequently seen in media reports. In addition, a distinction is made between those aircraft that operate under the control of a pilot and "autonomous aircraft [systems]" that operate according to preprogrammed instructions *without* the possibility of pilot intervention.
For purposes of this paper, ALPA is referring to aircraft, and the related required ground infrastructure, that are controlled by a pilot. We generally use the term RPAS, RPA, UA, and UAS interchangeably unless a specific reference to a single term is called out. Autonomous operation of aircraft is currently beyond the scope of regulatory

ALPA president Capt. Tim Canoll testifies on the importance of safe UAS integration at a Senate hearing in October 2015.

efforts in the United States and Canada, is not envisioned in the near future in unsegregated airspace, and is therefore outside the scope of the discussion of safe integration of UAS/RPAS into airspace used by other aircraft. Finally, much of the discussion in both the United States and Canada regarding appropriate use of RPAS focuses on privacy. ALPA believes that the appropriateness of the *mission* of an RPA is independent of the safe operation of that aircraft, and we will not discuss privacy concerns in this paper.

What are UAS/RPAS?

The aircraft under discussion in this paper are all flown by a person who is not physically located inside the aircraft. ALPA believes that these people should be referred to as pilots, and that these pilots should have the same training, proficiency, and experience as all pilots flying other aircraft in civil airspace. The aircraft themselves are typically divided into two or more subsets for the purposes of risk-based regulation. In both the United States and Canada, one dividing line is aircraft weight.

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Remotely piloted aircraft weighing less than 55 lbs. (25 kg) have been defined as small UAS (sUAS). These aircraft typically are flown within visual line of sight of the pilot in visual meteorological conditions, although there are initiatives under way by government and industry to facilitate civil operations beyond visual line of sight. Remotely piloted aircraft that weigh more than 55 lbs. are typically intended to operate beyond visual line of sight, will likely operate under instrument flight rules, and can be capable of operating above Class A airspace into the high Class E airspace (above 60,000 feet). While sUAS are frequently in the public spotlight, and believed to be the most prevalent type operating as well as the focus of the current rulemaking, they are typically intended to be operated at low altitude and away from airports. In spite of this presumed limitation, many of these aircraft have the performance to operate in the same airspace used by aircraft with people on board. Thus, for sUAS to pose a collision hazard with other aircraft, they must either inadvertently stray into occupied airspace or be deliberately flown there. For that reason, different risk analyses and mitigations need to be developed specific for this group of aircraft.

The larger UAS/RPAS are in fact the ones intended to be flown deliberately in the same airspace at the same time as other airspace users, notably airline aircraft, and so must be designed and flown such that they can safely and efficiently mix with those aircraft with the same level of safety assurance as is currently required for other airspace users. Many such aircraft are already in widespread use by many countries' military forces and some other government departments, operating domestically as well as in war zones. These large aircraft operate well beyond visual line of sight of the pilot using sophisticated electronics and with extensive coordination to preclude interference with civil traffic.

A further subdivision is under consideration by regulators as well, that of a group of aircraft that are extremely small, typically 2 kg or less. This "micro" classification would potentially allow operations within narrow parameters based on a presumed lower risk. It should be noted, however, that 2 kg encompasses many of the most popular consumer/recreational UAS, some of which have the performance to fly well beyond the envisioned narrow limits for micro operation.

Finally, the discussion of remotely piloted aircraft also includes the intended use. That is, whether the aircraft is intended for recreational use by hobbyists or is intended for nonrecreational use such as in pursuit of a business—commercial or "for compensation or hire" applications or in pursuit of research by not-for-profit organizations. The proposed set of regulations published by the FAA in early 2015 applied to the use of RPAS for commercial purposes. Since then, FAA has approved approximately 2,500 exemptions (under the so-called "Section 333 process") for commercial use of RPAS. In Canada, nonrecreational use has been permitted for several years through issuance of Special Flight Operations Certificates (SFOCs) to address potential interference issues in civil airspace (1,672 SFOCs were issued in 2014 alone). Yet sightings of RPAS by pilots in airborne aircraft are being reported at a rate on the order of 100 per month. It seems implausible that all these encounters are by commercial users, so ALPA's conclusion is that a large number of noncommercial, recreational RPAS are being operated well above any recommended maximum altitude and within close proximity to busy airports, which is a clear indication of the need to address the operation of the aircraft themselves, regardless of the nature of that operation.

Integration Challenges

As with any new technology introduced into the aviation system, there must be a means to safely integrate it with existing systems, operations, and infrastructure. This is a major challenge for UAS/RPAS when being introduced into unsegregated airspace since they use multiple aircraft designs (e.g., fixed wing, rotary winged, multi-rotor) with different propulsion sources (electric, small gas engines, even turbine powered), diverse applications of distributed architectures for avionics, and their pilots have widely varied levels of training, experience, and qualification. These are just a few of the many complex issues requiring thorough and methodical approaches to ensure safety of the airspace. The technologies that must allow what even novice pilots certificated under current protocols know as the fundamentals—aviate, navigate, and communicate—are numerous in the UAS/RPAS platforms and designed in a multitude of configurations.

This is no different for an RPA than other new technologies (e.g., jet engine, GPS, or TCAS) that have earned their way into safe use in the national airspace system (NAS). The technology must be thoroughly evaluated to be understood, potential failures must be identified and mitigated, and there must be a proven safety case for the intended operations before they can be introduced into the comprehensive system of safety and operation requirements that exists in today's public airspace. In addition, once UAS/RPAS have begun to be integrated, there must be ongoing evaluation and feedback to address safety issues revealed through operating experience. Safety gaps, if not promptly identified and addressed, can unknowingly lead to the transference of the safety-mitigation responsibility to other airspace users, thus adding to the complexity of UAS/RPAS integration if these systems do not operate in a manner that is easily managed or as intended. Many fly low and slow, while others fly at very high altitudes for long durations compared to manned flight operations, creating new challenges for integration into an already highly complex air traffic control (ATC) system. These aircraft require unique technologies to accommodate the relocation of the pilot from the onboard cockpit to a remote control station including the unique elements of remote control of the aircraft as well as necessary capability to "see and avoid" other NAS users.

Current and future RPAS operating in complex, dynamic airspace require highly advanced, reliable technologies that safely mitigate for the absence of a professionally trained pilot onboard the aircraft. The first such technology for RPAS is the requirement for vital communications about all things related to flight—not simply

ATC communications, but the actual process of the pilot controlling the aircraft, which for RPAS must be accomplished by a communications link. These communications systems are referred to as Command and Control (C^2). C^2 is the combination of radio or satellite equipment and frequencies to enable the transfer of significant amounts of data to and from the aircraft, including inputs for all the collective technologies required to safely operate a RPAS. This is a key difference between RPAS and conventionally piloted aircraft. In today's aviation system, essentially the only two-way communication with aircraft is for air traffic control or various operational needs such as weather, gate information for airlines, and so forth. In every case, procedures exist such that if those communications are completely disrupted, safety is maintained and the aircraft continues to operate under the control of the flight crew in a predictable manner (e.g., lost communications procedures) with minimal disruption to the system and no more than a minor degradation in safety. The added dimension in RPAS operations that the basic control of the aircraft (speed, altitude, direction) must be effected through the use of two-way communications (the C^2 link) introduces a major area of risk that must be mitigated. Should these communications be lost, the pilot has effectively lost the ability to control the aircraft. Thus, the communications required to control the flight path and aircraft systems must be designed to be extraordinarily reliable, and in addition, must operate with little or no delay or "latency" due to the need to process digital signals, transmit a command over long distances, and cause the appropriate response by the aircraft. In addition, reliable flight path control systems must be built into the RPA in order to safely and predictably maneuver the RPA in the event of a lost C^2 link.

The second key technology necessary for safe operation of RPAS in unrestricted airspace is "detect and avoid" (DAA). DAA is the term used for the RPAS capability necessary to replicate a human pilot's well-established responsibility to "see and avoid" other aircraft, regardless of whether the aircraft are under the control of ATC. For purposes of defining technical

U.S. Navy photo by Photographers Mate 2nd Class Daniel J. McLain (RELEASED)

St. Inigoes, Md. (June 27, 2005) Pictured are (front to back, left to right) RQ-11A Raven, Evolution, Dragon Eye, NASA FLIC, Arcturus T-15, Skylark, Tern, RQ-2B Pioneer, and Neptune.

standards, the overall DAA capability has been divided into a capability to remain well clear of other aircraft and, if that technology fails or is ineffective, an additional capability to actively avoid a collision.

In theory, the two functions could be independent or could be the same technology achieving two different standards of performance. Collectively, they must be able to effectively mitigate any risk of midair collision down to some acceptably small value. ALPA believes that, until it can be conclusively shown that a DAA technology can satisfy that mitigation requirement, the design assumption must be that RPAS be equipped with

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active collision-avoidance technology to safely maneuver against collision risks while interacting with other airspace users. Thus both technologies are to play a vital role in the integration of RPAS into the airspace used by other aircraft. In tandem with the projected air-traffic volumes, the result will likely become more dynamic, requiring mitigation technologies to not only perform safely but also incorporate significant scalability or the ability to adapt and grow to accommodate for future flight operation growth.

RPAS have created and revealed many complex challenges for airspace management; however, with the creation of these challenges, RPAS may very well provide future-state safety technologies that could be shared in manned aviation, with possible harmonization outcomes. But for now, the NAS and its users demand collaborative safety-focused mitigations for reliable and repeatable end-to-end flight operations. As aviation professionals and airspace users, we must lean forward with a strong, unified, fact-based position to ensure RPAS/sUAS meet aircraft certification, technology standards, and pilot certifications to maintain the safety of the airspace system.

Safety Statements on Specific Technologies, Methods, and Analysis

Reliability, Safety, and Operation of RPAS Communications

RPAS required communications capabilities reflect both the traditional role of ATC communications with all aircraft and the unique aspect of RPA that the means for the pilot to interact with the aircraft is wholly dependent on reliable, accurate two-way communication rather than any mechanical or electronic cockpit controls and displays. The suite of communications capabilities is known as the “command and control” system (C^2). The C^2 capability is the first of two fundamental capabilities that must be defined, developed, refined, and made an integral part of any UAS/RPAS design. The second, “detect and avoid,” is discussed later in this section.

An effective C^2 capability is integral in how the pilot controls the aircraft, directs the course flown, and communicates with ATC without being present in the aircraft. In other words, the C^2 communication link is the wireless digital extension of the pilot that allows him or her to fulfill the responsibility to aviate, navigate, and communicate. The ability of the remote pilot to monitor aircraft status, maneuver safely, and interact with ATC in the same manner as pilots on board their aircraft relies on the C^2 performing optimally and being available continuously. However, C^2 link losses can and do happen. Like the loss of any system on any aircraft, the failure of the link must be evaluated and, unless a means is provided to render that failure nearly impossible, mitigations must be established to prevent the loss of this system from resulting in loss of the aircraft or creation of a hazard to other aircraft in the airspace or people and property on the ground.

This “lost link” is a failure unique to aircraft without an on-board pilot and must be addressed to ensure the pilot can remain in control of the aircraft. If the C^2 link is lost, the pilot has been effectively removed from the role of controlling the aircraft, monitoring its systems, and communicating with ATC in the conventional manner. The aircraft, with the pilot now removed, must remain stable and operate in a predictable manner. Procedures must be developed to attempt to reestablish communications or to address the aircraft now operating without the possibility of pilot intervention. Furthermore, the aircraft must continue to be able to maintain well clear or perform collision-avoidance maneuvers against other aircraft. Therefore, there must be means both to ensure that the RPAS remains within the defined airspace and that the hazards to other aircraft in these scenarios are safely mitigated.

Considerable technological challenges are being addressed by industry and regulators, but that must be overcome for the safe integration of RPAS into airspace used by airlines to take place. While many UAS/RPAS have preprogrammed instructions upon which that aircraft relies in a lost-link event, the fact that the pilot is no longer in control of the aircraft when the aircraft is potentially near airspace occupied by other conventionally piloted aircraft is a safety concern. At present, no requirement exists to report all such events to a government agency (e.g., FAA or NTSB), so ALPA is concerned that the frequency of "lost link" with the UAS/RPAS is more prevalent than is currently being reported.

Even without a loss of communications, latency in those communications—the time between transmission and reception of a command to successfully operate the UAS/RPAS—is another unique aspect of RPAS operations that must be addressed. Unlike the professionally trained pilot on board, whose actions, reactions, and external communications (e.g., control inputs, perception of instrument readings, reactions to ATC instructions) are real time, all of the interaction between the aircraft in the air and the pilot on the ground must be translated into a discrete, reliable radio signal, transmitted across some distance, then processed by the receiving station. All of this takes some time even under ideal conditions, and must be made to work safely in a system that typically expects immediate communications between aircraft and controllers or other airspace users. The question of "how long is too long" is key. Latency periods vary and can be affected by many factors. Thorough analysis of all these factors and mitigations of conditions that result in latency that is unacceptably long must be completed for safe integration to occur in airspace used by other aircraft. Latency is currently being studied to better understand its occurrence and duration, combined with the varying degrees of other UAS/RPAS C^2 vulnerabilities and security issues and failures creating complex safety hazards for UAS/RPAS integration. To effectively address these issues, the C^2 system must meet a required communication performance (RCP) level that itself must be defined. The composition of C^2 RCP should include signal integrity, availability, and reliability requirements for C^2 data, voice, and any collision-avoidance sensor links to be designed to meet a target level of safety and security required by the FAA in order to safely fly near manned commercial aircraft operations.

A unique issue involving the radio frequency spectrum that is commonly accessed for sUAS is that the spectrum is unprotected. Lack of a protected spectrum necessitates additional mitigation strategies or technologies to protect RPAS from lost-link conditions and cross or multiple-use scenarios as well (meaning every transmission between a specific aircraft and its pilot must, with a high degree of certainty, be between only that aircraft and only that pilot, even when dozens, if not hundreds, of other RPAS are similarly communicating with their pilots. ALPA strongly believes that design standards must be developed both to ensure that the RPA remains within the defined airspace when operating normally and that the hazard of operation in the absence of control commands is mitigated.

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If RPAS cannot reliably maintain a C^2 link, lost-link mitigations should require safe modes to prevent flyaways or scenarios that pose a collision risk. Mitigations for RPAS spectrum interference, weather, terrain, and obstacles (man-made or natural) should be developed to ensure safe operations. If lost link occurs, mitigations to safely perform auto-hover, auto-land, return-to-home and geofencing boundary protection must be incorporated into the navigation and control systems for a RPAS to safely land (without harm to person or property) or reestablish C^2.

Detect-and-Avoid Technology Capabilities

Detect and avoid (DAA) is the second fundamental capability that UAS/RPAS need to operate safely in the same airspace with other aircraft. DAA must replicate two basic responsibilities of on-board pilots. The first is self-separation (i.e., staying well clear of other aircraft) and then, if that action cannot be accomplished, the second responsibility of active collision avoidance (with or without pilot action, based on the circumstances). Collision avoidance in this context is a critical redundancy—for a collision to be imminent, other safety systems have failed, but history says that is possible, however unlikely, so there must be a "last line of defense" given the potentially catastrophic consequences of a collision. It should be emphasized that while these two capabilities are discussed separately, it is not a foregone conclusion that the capability be provided by separate pieces of equipment. The ultimate goal remains to avoid, to an extremely high probability, any possibility of midair collision between aircraft operating in the same general area. ALPA is of the strong belief that both capabilities must be provided, but recognizes that there are multiple means of achieving that goal.

The responsibility to avoid being hazardously close to other aircraft is a two-way street. While these functionalities and capabilities in manned aircraft are accomplished by a combination of first-person pilot skill (training, scan technique, etc.) and electronic means (transponder detection equipment such as TCAS), a UAS/RPAS must rely solely on electronic means. In addition to the RPA's ability to detect and avoid other aircraft, likewise other pilots of manned aircraft must be able to "see and avoid" an UAS/RPAS that could pose a collision threat. Realistically, given the various sizes, aircraft profiles, and performance of RPAS and particularly sUAS compared to commercial airliners or even general aviation aircraft, many factors impact pilots' ability to visually acquire RPAS traffic. Most sUAS and many larger platforms are too small, slow, or lack the conspicuity necessary to be seen by the human eye until the aircraft is dangerously close, so the mitigation method for the RPA to be detected by pilots of manned aircraft must be electronic and to a high enough standard to compensate for the manned aircraft pilot's decreased ability to detect the relatively smaller RPA. No requirement is currently in place that ensures an RPA can be electronically identified by ATC or by other aircraft in the airspace.

Systems are, however, under development that could help address the need for this capability. Technological advancements in support of airspace modernization efforts, such as NextGen in the United States, need to be monitored for applicability to RPAS. Automatic Dependent Surveillance-Broadcast (ADS-B) capitalizes on the extremely accurate positioning capability provided by GPS and similar space-based systems. That ability to know an equipped aircraft's accurate GPS position can be useful in identifying the position of all aircraft. Another such valuable safety technology is a new airborne collision-avoidance system for all aircraft, known as ACAS X and Xu (a UAS-specific variant). The current traffic collision-avoidance system (TCAS) is over 25 years old and, while it has proven to be an invaluable safety enhancement, it is at its design limits. ACAS is designed for harmonizing NAS users with a common interoperable and scalable collision-avoidance systems with associated NextGen technologies to meet the safety standards required by the complexity of modern operations. Both ADS-B and ACAS programs represent critical improvements to the safety of the airspace. Both, as evolving programs, must continue to be

Photo by: USAF Senior Airman Larry E. Reid Jr.

funded to ensure continued safety. It is these very technologies that will enable RPAS to "see and avoid" other airspace users.

This total reliance on electronic means to avoid collision raises yet another condition that must be addressed in the design and operation of RPAS. If the RPA pilot is an integral part of identifying and avoiding other traffic, failure of the C^2 system while DAA and the pilot are attempting to maintain well clear or perform collision avoidance must be addressed. For some system architectures or system failures, loss of the communications link could result in the DAA failure as well, leaving the RPA pilot without any surveillance information or control. There must be a highly automated protection capability residing solely onboard the RPA not only to fly predictably on its flight plan during these types of "lost link" events, but to retain the capability to avoid becoming a hazard to other aircraft. The flight-protection capability of the RPA should preclude adversely impacting other airspace users, to maintain well clear and/or execute collision avoidance until the aircraft lands or regains C^2 and safely continues its operation. DAA technical standards and resulting designs for on-board systems should never result in the transference of safety burdens, such as maintaining separation or collision avoidance, to other airspace users.

Safety Systems

In recent years, RPAS have been highlighted for their value in accomplishing vital tasks while keeping a human pilot out of harm's way—primarily military in applications. The technology that permits military aircraft to safely and successfully accomplish their wartime missions has been translated into the basis for a potentially lucrative civil market. Large RPAS currently in use by government and private agencies generally have the same design characteristics as their military counterparts or they are in fact, re-roled military aircraft. Either way, the design emphasis is on mission accomplishment. Safety is a consideration, of course, because even a combat aircraft is expected to accomplish the mission without introducing unnecessary risk to its own survival, an on-board pilot, or people on the ground. However, safety is not the primary design consideration.

Conversely, civil aircraft with on-board pilots currently operating in the NAS, whether recreational, business, or air carrier, are, with few exceptions, designed with safety as the primary goal. Decades of accident and incident experience involving failures (both anticipated and unanticipated) have led to a complex, robust set of baseline safety standards for aircraft design as well as detailed feedback mechanisms to enable operating experience to be collected and evaluated for any needed ongoing changes. Single failures that can result in loss of life or significant damage are generally not allowed to exist. Critical systems are designed with multiple levels of redundancy; failures, singularly and in combination, are analyzed and, unless proven to be extraordinarily unlikely, are required to be mitigated by other systems, procedures, or means. No requirement for designing RPAS with such safety systems currently exists. Although by definition, a design deficiency in an aircraft with no one on board cannot endanger the occupants, the potential of an RPA becoming a hazard to other aircraft or to people and property on the ground cannot be ignored and must be fully evaluated and mitigated.

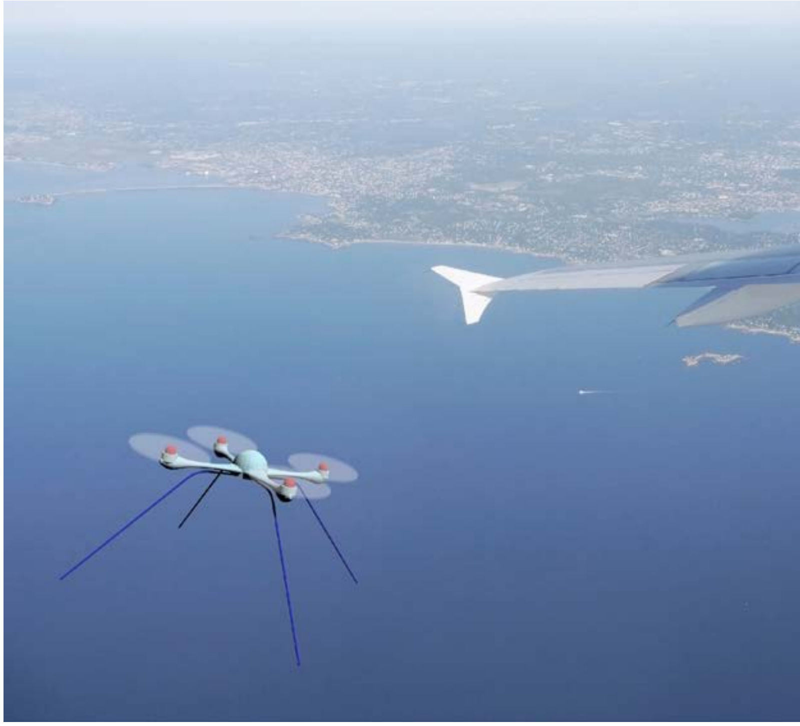
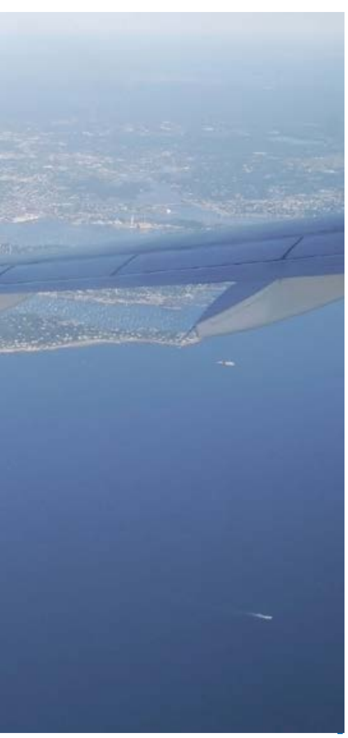


Photo by: iStock

Although DAA and C2 systems are critical to the safe operation of the aircraft and are currently the focus of significant analysis, these are not the only systems that must be designed with safety as the primary goal. Flight control malfunctions, various mechanical and electronic component failures, and propulsion-unit failures need to be identified, analyzed, and prevented/mitigated where necessary. If the aircraft is expected to maneuver in response to ATC commands, collision warnings, or weather encounters, structural strength requirements must be defined and tested. Since, unlike for other aircraft in the airspace, no standards yet exist for any of these considerations, the safety of an individual design can only be evaluated on a case-by-case basis.

Basic safety systems on nearly all aircraft operating in the airspace today include the ability to display/report speed, direction, and altitude above sea level. As a practical matter, large RPAS whose designs trace to existing operational aircraft as discussed above, have this capability. However, no requirement currently exists for any such capability in an RPA of any size or role. This becomes significant when a collision-avoidance mitigation for some types (most notably the proposed limitations on sUAS) is to restrict the operation to areas not typically occupied by large numbers of other aircraft. A rapidly growing problem is the dramatic increase in reported interference or unacceptable proximity between commercial airline traffic and RPAS. Most, if not all of these encounters are with sUAS. sUAS that are operating now are, and may reasonably be expected to continue to be, capable of performance that would allow them to climb to altitudes well above those intended as the maximum for safe operation and fly faster than they are allowed to fly. Yet most have no capability (nor are they currently required to have the capability) to measure, display, or indicate altitude or airspeed, nor do they communicate their position to the pilot. In addition, there is no requirement that any technology be employed to prevent an operation at a prohibited speed or altitude or to encroach on airspace in which operations are prohibited. Although this is also true for many manned aircraft operations, a significant mitigation is provided by pilot requirements (training, knowledge testing, and licensing).



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Safety Analysis

To critically and completely analyze the introduction of new technologies and their potential impacts on the entire environment, safety cases must be developed with the best empirical data available to support the findings. As mentioned earlier, there are multiple UAS/RPAS with a wide array of similar technologies and all of these aircraft, if they are to be allowed unrestricted access to airspace, must be evaluated individually or commonalities must be identified to allow collective analysis. To examine how integration of this magnitude can be safely accomplished requires complex research studies to collect data, perform analyses, and determine if the outcomes meet the hypotheses and hopefully gain industry and public acceptance to use the study for safety analysis.

It's time-consuming and exhaustive but paramount in the importance to ensure the final analysis is as accurate as possible. To accomplish this integration and other future projects, more analysis is required to understand the dynamic and complex systems that compose the NAS. There are not enough empirical studies to fully understand airspace, ATC, flight operations wrapped in regulation with methods expressed in modeling and simulation to understand the impacts of integrating UAS/RPAS. Airspace operations analysis is critically absent. While we understand the regulatory side of airspace classes, more data based on altitude layers (e.g., ground to 3,500′ AGL; 3,500–10,000; 10,000–

FL180) could improve quantitative outcomes through system examinations using alternative methods to "see the whole picture" as it pertains to all cooperative and uncooperative air traffic activities in the NAS.

Human in the Loop—The Pilot

Regulators have devoted considerable energy in attempting to determine the skills, background, and training necessary to safely control any aircraft operating in the airspace. In most instances, these attributes are varied based on the size and complexity of the aircraft and the nature of the operation, but always with the common objective of safeguarding other aircraft operating in the airspace as well as people and property on the ground. Translating this philosophy to a fleet of aircraft controlled by someone on the ground, which are therefore highly automated and of hugely diverse size, complexity, and performance, has proven to be a challenge.

ALPA believes that the fundamental functions of operating an aircraft in a safe manner must be maintained at the same level of safety assurance regardless of the location of the pilot or levels of automation. At the center of current commercial aviation flight operations is a well-trained and qualified professional pilot, and that pilot is the single most important safety component of any commercial aircraft.

Photo by: iStock

The ease with which many RPAS can be flown "out of the box" should not be a substitute for pilot training. The physical manipulation of controls to manage speed, direction, and altitude are basic skills all pilots must master, but far more important is the knowledge of airspace limitations, weather, ATC principles, hazard identification and risk analysis, the ability to anticipate trouble, and understanding the interaction of all aircraft in the area. These skills are critical to safe operation and don't come in the box with an easy-to-fly RPA. Government public awareness initiatives such as the FAA's "Know Before You Fly" program are an excellent start to a near-term education effort for RPAS pilots, but a longer-term solution is needed.

ALPA is equally concerned about the lack of any required demonstration of proficiency for a prospective RPAS pilot. The currently envisioned categorization of these aircraft, as mentioned above, is based solely on weight. Yet within any single such category, the designs available now include both fixed wing and rotary wing (single or multi-rotor) with electric, internal combustion, and even turbine powerplants. For aircraft with on-board pilots, separate, specific training and proficiency demonstration would be required to ensure safety of all aircraft in the airspace.

An RPAS that is operated for commercial purposes should be required to operate as a part of commercial aviation through compliance with regulations accompanying certification standards to meet the target level of safety that is performed reliably and repeatedly by well-trained commercial pilots and their aircraft today. Like commercial operators today, RPAS operators performing commercial or "for hire" operations should be required to meet all the certification and equivalent safety requirements of a commercial operator, and the pilots flying the aircraft must meet equivalent training, qualification, and licensing requirements of pilots of manned aircraft in the same airspace.

Finally, it should be noted that, by definition, it is impossible for an RPAS pilot to react to anything other than an explicitly annunciated malfunction.

A pilot on board an aircraft can see, feel, smell, or hear many indications of an impending problem and begin to formulate a course of action before even sophisticated sensors and indicators provide positive indications of trouble. This capability is necessarily lost without a pilot on board, so the margin of safety it represents must be replaced by other means.

Current and Future Efforts

Rulemaking Efforts

The FAA established the sUAS Aviation Rulemaking Committee (ARC) in 2008, charged to develop standards and regulations unique and appropriate to small sUAS (55 lbs. and less), whether used for commercial or hobby purposes. In 2009, the sUAS ARC submitted its recommendations to the FAA. The FAA's 2015 notice of proposed rulemaking for commercial operations, mentioned above, was as a result of the ARC. In its own effort to establish a regulatory framework for sUAS, Transport Canada published a notice of proposed amendment in 2015 as well. To download the ALPA comments submitted, visit the ALPA UAS website at *www.alpa.org/uas*.

In 2011, another UAS ARC was chartered for three years to make recommendations for standards and regulations to safely integrate the remaining (i.e., large) RPAS into all airspaces. Due to the large volume of regulations and guidance material needing review for recommended changes or amendments to regulations such as 14 CFR Part 91 and 61 or subparts by the UAS ARC work groups, the FAA extended its charter in June 2014 until June 2016. This extension will allow the well-staffed and knowledgeable subject-matter expert members to continue and complete without compromise what has been a larger and more difficult process than originally expected. Thus, as of late 2015, the actual rules in place governing unmanned aircraft operating in public airspace remains extremely general, limited only to those provisions in regulation that prohibit any operation that endangers the overall safety of aircraft operating in the airspace. No specific body of regulations yet exists in the United States or Canada that covers these aircraft, and the rest of the world is at best a patchwork. Perhaps just as troubling, the first rules to be on the books will be limited in scope to sUAS for commercial applications only in the United States, and in Canada the similar narrow focus on sUAS includes an intent to exempt very small UAS and recreational RPAS up to 35 kg (77 lbs.) from formal regulation.

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Development of Technical Standards

In addition to the regulatory framework required to establish safety standards for RPAS of all sizes, considerable effort is being expended by both government and industry stakeholders to establish technical standards for the most critical (and arguably most unique) systems necessary for safe operation of RPAS in the airspace. Those are DAA and C^2, both discussed in detail above. While not specifically required for safe operation of a given aircraft, development of these standards is critical to the safe integration of significant numbers of RPAS into airspace used by other aircraft. ALPA and many other stakeholders are participating in the development of the standards.

As both the regulatory structure and technology evolve and mature, additional standards may well be necessary. For example, although technology exists to limit the operation of RPAS in three dimensions and thereby reduce the possibility of inadvertent entry into airspace not intended for operation (geofencing), no requirement for such a capability currently exists. Eventually, for the technology to be effective, standards will be necessary to ensure the integrity, effectiveness, and interoperability of such systems, as well as to provide regulators a means to ensure compliance with a performance requirement.

Conclusions

1. ALPA reiterates our support for development of UAS/RPAS technologies and the potential societal and economic benefits they represent. ALPA stands ready to continue the existing collaborative relationships with FAA, Transport Canada, and industry to further develop standards necessary to ensure the continuing safety of the NAS and the safe integration of UAS/RPAS.
2. The pressure for rapid integration of RPAS into airspace used by other aircraft must not result in approvals to operate prior to completing safety analyses and incorporation of effective technologies to mitigate risk.
3. Integration must not require the transference of safety burdens, intentionally or unknowingly, to other airspace users.
4. Standards and technologies for UAS/RPAS must be in place to ensure the same high level of safety as is currently present before a UAS/RPAS can be authorized to occupy the same airspace as airlines, or operate in areas where UAS/RPAS might inadvertently stray into airspace used by commercial flights.
5. Critical to safe UAS/RPAS integration, the decisions being made about UAS/RPAS airworthiness and operational requirements must fully address safety implications of UAS/RPAS and complete interoperability functionalities (e.g., DAA) of these aircraft flying in, around, or over the same airspace as manned aircraft, in particular airline aircraft.
6. A well-trained and experienced professional pilot is the most important safety component of the commercial aviation system. The role of the pilot is a major area of concern within the UAS/RPAS and piloted aircraft communities. Removing the pilot from direct control of the RPA appears to be an additional complexity that will require careful consideration to ensure safety levels are maintained.
7. UAS/RPAS pilots should be highly trained, qualified, and monitored to meet the equivalent standards of pilots who operate manned aircraft in either private or commercial operations.

Recommendations

Near-Term, Immediate Actions

With the anticipated explosive growth in UAS sales and use, and the increasing reports of hazardous encounters with RPAS by airlines, there are immediate actions that must be considered. ALPA believes that a significant step toward the eventual solution to safely integrating UAS into the NAS includes four fundamental elements:

1 EDUCATION

Anyone who plans to fly UAS must understand the aircraft, the airspace, the operating environment, and the other aircraft that could be encountered while flying.

In the case of UAS that are flown for compensation or hire in civil airspace, the pilot must hold a commercial pilot certificate to ensure he or she possesses the appropriate skill and experience to meet safety standards designed to protect the public in the air and on the ground.

Those flying UAS for recreational purposes must adhere to the regulator's guidelines, including potential minimum-age requirements and operational parameters such as speed, altitude, and distance from the ground control station.

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2 REGISTRATION

ALPA supports the recommendations that were developed by a Department of Transportation task force on creating a national registration database for RPAS. Gathering basic information about the identity of the individual purchasing the UAS not only allows law enforcement authorities to identify the owner if the UAS were to encounter a problem, but it helps make clear the serious nature of operating a UAS in the NAS and the responsibility to safeguard public safety. Although not a recommendation of the task force, ALPA believes that registration of the UAS at the point of sale is necessary in order to ensure maximum compliance with registration rules.

3 TECHNOLOGY

If UAS, either intentionally or unintentionally, are operated in airspace that airliners use, airline pilots need to be able to see them on cockpit displays, controllers need the ability to see them on their radar scopes, and UAS must be equipped with active technologies that ensure that the UAS is capable of avoiding collision with manned aircraft. In these types of operations, technology must enable the pilots to control and interact with them not only in the same manner as if the pilot were on board, but to a higher standard due to the manned aircraft pilot's decreased ability to see most RPAS.

If a UAS is restricted by regulations or guidelines from operating in a particular geographic area and/or altitude, it must have technology that cannot be overridden that limits the geographic areas and altitude in which it can operate.

4 PENALTIES AND ENFORCEMENT

UAS pilots must be properly trained and understand the consequences of possible malfunctions. Anyone flying a UAS that is a hazard to other aircraft in the airspace, especially those who choose to do so recklessly near airports or by operating unairworthy RPAS, must be identified and appropriately prosecuted. We support the criminalizing of intentional unsafe operation of UAS and penalties for unintentional unsafe UAS operations.

Longer-Term, Strategic Goals

1. Regulations should be developed that specifically addresses UAS/RPAS operators, aircraft airworthiness, operations, aeromedical requirements, and pilot certification. Any UAS/RPAS-unique or UAS/RPAS-specific regulations must be comparable and compatible with currently existing regulations for other airspace users.
2. UAS/RPAS are inherently different aircraft from manned aircraft, and should be required to be equipped with robust safety-based technologies designed with "well clear" and "active collision avoidance" functionalities within their system architectures in order to maintain the current level of safety in the NAS.
3. Support government efforts to ensure that all the components of UAS/RPAS certified for use by the military and other government agencies do not adversely affect the NAS level of safety prior to their unrestricted operations outside of segregated airspace.
4. Pilots of UAS/RPAS that are used for commercial purposes must be commercially licensed with an instrument rating for the category and class of aircraft to be flown and have appropriate aeromedical certification to ensure the continuity of safety that now exists in the NAS.
5. In the United States, Congress should work with industry to develop an appropriate UAS/RPAS integration funding mechanism within the FAA reauthorization. In Canada, Transport Canada should ensure that adequate resources are available to support the extensive effort that remains to develop regulations and adequately oversee this developing sector of aviation. ▲

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