Safety forum unravels clues to how unmanned aircraft systems could gain less-restricted access to U.S. airspace.

BY WAYNE ROSENKRANS

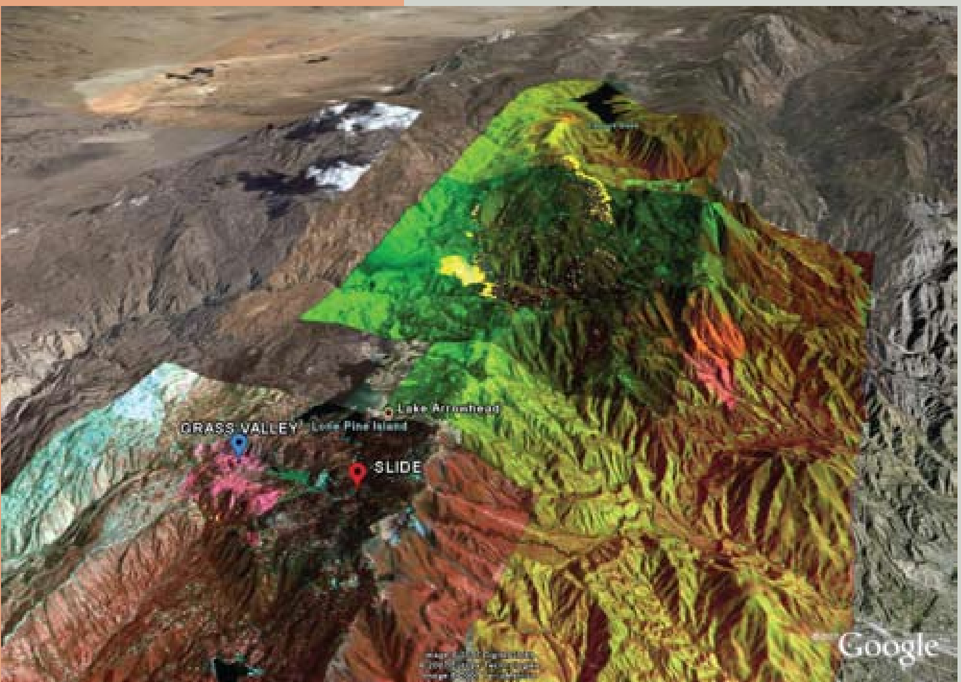
Detect, Sense and Avoid

Highly reliable *detect, sense and avoid* (DSA) technology as early as 2012 could begin to liberate large unmanned aircraft systems (UAS) from most of today's restrictions on sharing the U.S. national airspace system (NAS), according to several UAS manufacturers.[1]

In presentations to the U.S. National Transportation Safety Board (NTSB) Public Forum on Unmanned Aircraft Systems in April 2008 in Washington, however, they voiced concerns about whether UAS safety policy, airworthiness standards, operating regulations and other prerequisites for this coveted, relatively "unfettered" integration of UAS into the NAS will be ready in this time frame.

Prompted by the implications of one UAS accident in 2006[2] (*ASW,* 12/07, p. 42) and one in 2007,[3] the forum contrasted future integration of UAS into the NAS with current U.S. Federal Aviation Administration (FAA) certificate of waiver or authorization (COA) operations and other alternate means of regulatory compliance now available to the UAS industry. Participants also saw a case study of U.S. National Aeronautics and Space Administration (NASA) missions that

U.S. National Aeronautics and Space Administration



U.S. National Aeronautics and Space Administration

The Altair variant of the Predator B first flew wildfire-imaging missions for NASA in 2006. Above, data-linked infrared images similar to this example helped prevent injury after five U.S. firefighters were killed in a late October wildfire.

helped to save lives and property during wildfires in California and other Western states.

The typical UAS comprises an unmanned aircraft (UA) without a cockpit; a ground control station (GCS) occupied by the pilot(s) and other mission specialists; and command, control and communication equipment and data networks that link the GCS and the aircraft.

Wildfires and Pipelines

The NASA wildfire missions and U.S. Department of Energy applications were selected by the NTSB as prominent examples of non-military uses of UAS in the NAS. Historically, scientific projects involving UAS were conducted mostly within restricted areas, said Brent Cobleigh, deputy mission director for exploration, NASA Dryden Flight Research Center. NASA's uses for the General Atomics Predator B, for example, include surveillance of hurricane formation in the eastern Caribbean, polar ice melt measurement and high-altitude atmospheric research of long duration, he said.

In a cooperative emergency fire fighting support mission with the U.S. Forest Service and the National Interagency Fire Center, eight Predator B flights were conducted in mid-2007 with durations as long as 20 hours, Cobleigh said. On some, the aircraft loitered about one hour over each of 10 fires at locations in several states. It transmitted burn-area emergency response imagery for use by firefighters within five to 15 minutes.

The many public-sector operators of UAS could help reduce their risks while flying in the NAS by voluntarily adopting airworthiness, flight operations and pilot qualification standards equal to or stricter than the FAA's requirements for manned commercial aviation, said Randy Stewart, senior aviation policy officer, U.S. Department of Energy. Examples of the department's civil UAS applications include low-cost pipeline patrol and response to biological or radiological events without concern about pilot exposure.

"We currently have 17 COAs for UAS operations with six aircraft types in 2008–2009," Stewart said. By tightening standards in recent years, the department experienced — for manned aircraft and UAS combined — a 92 percent reduction in its fatality rate to 0.67 per 100,000 flight hours and a 64 percent reduction in its aircraft accident rate to 2.0 per 100,000 flight hours, he said.

Officials' negative attitudes about the value of airworthiness standards for UAS began to shift in 1995, he recalled, after the manufacturer of the Altus UAS found four design flaws and then implemented changes based on a comparison of its design to U.S. Federal Aviation Regulations (FARs) Part 23 requirements.

"We cannot wait until 2015 or 2025 — we have ongoing operations, and as a department we have to formulate policy that is adequate for the scope of our operations," Stewart said. "Something needs to be done to keep [UAS integration] on track now because UAS activity is occurring now."

FAA Flight Restrictions

The current policies and regulations enable two basic categories of UAS operation, said Doug Davis, manager of the 2-year-old FAA Unmanned Aircraft Program Office. One category enables unrestricted flights by military/government UAS operators — which are responsible for their own airworthiness — in airspace that is segregated from NAS users. The other category generally enables, on a case-by-base basis, restricted flights in the NAS if either the military/government operator

U.S. Air Force

Global Hawks routinely take off and land near manned aircraft using airports outside the United States, and they fly under instrument flight rules.

or the FAA has certified the UAS airworthiness. Operators that primarily use segregated airspace — special use airspace comprising restricted, prohibited and warning areas — include military services and government agencies, collectively called *public users.*

To enable flights in the NAS by public users, the FAA for 10 years has been granting COAs; 82 COAs were active as of April 2008, said Ardy Williams, air traffic manager–UAS, FAA Air Traffic Organization. Each is basically a waiver of some FARs, with risk mitigation by specifying operating limitations, for periods of three to 12 months. The FAA projects that up to 400 applications for COAs will be received in 2013, depending on regulations in effect then and other factors.

To enable flights in the NAS by a *civil user,* an entity other than a public user, the FAA can grant either a special airworthiness certificate, typically in the experimental category, or a type certificate. In each case, the FAA itself has certified the airworthiness of the UAS.

Around mid-2008, the FAA expects to complete a revision of its strategic road map for regulation of UAS with improved definition of work assignments, Davis said. Related activities include a focus on guidance for issuing special airworthiness certificates in the restricted category; review of applicability of FARs Part 23 airworthiness regulations to UAS; review of applicability of FARs Part 27 rotorcraft regulations to UAS; review of GCS technology; and review of automatic takeoff and landing technology.

The FAA Unmanned Aircraft Program Office and Air Traffic Organization also are developing several initiatives to study the effects of the growth of UAS operations on air traffic control and to provide standardized training on UAS to all air traffic controllers. "We routinely restrict the simultaneous or concurrent operation of unmanned aircraft with civil manned operations [in airport traffic patterns], particularly at civil use airports [and civil-military joint-use airports] that allow for those types of operations," added Bruce Tarbert, NAS Integration Team lead in this office. "We develop [airport] procedures on a case-by-case basis [and] ensure that a notice to airmen is issued. … If airfields are uncontrolled, we require UAS pilots to monitor the common traffic advisory frequency or unicom frequency … as a [risk] mitigation requirement."

Davis said that the FAA has prioritized its UAS activities based on industry economic projections. "We found several market surveys that indicated that over the next seven to eight years, the preponderance of unmanned aircraft are going to be under 20 lb [9 kg], so clearly we have a market need that is driving the direction that we are taking," he said. Among primary FAA activities to develop new policy, regulations and/or regulatory amendments and guidance for civil commercial UAS is a new aviation rulemaking committee that began meeting in May 2008. This committee will draft a regulation for the line-of-sight commercial use of UAS during daylight hours under visual flight rules [VFR] with limitations on maximum weight, airspeed and altitude, Davis said.

With FAA oversight and involvement of the U.S. Department of Defense (DOD), RTCA Special Committee 203 since 2004 has pursued consensus civilian standards for DSA functions and command-and-control functions for UAS among other tasks.[4] "Somewhere in the realm of 2020–2025, we will see a fully certificated avionics suite that will meet the full FAA requirement for civil UAS applications," Davis said.

Military Priority

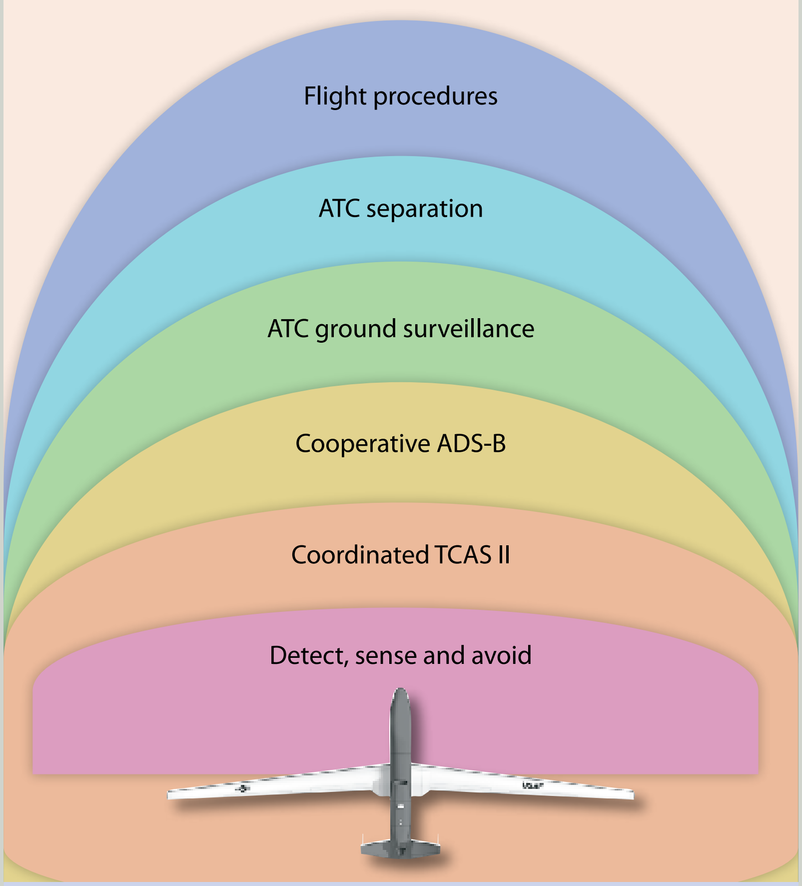
U.S. military services have developed UAS risk-analysis processes and safety mitigation methods that are instructive for operating civil UAS in the NAS, said Lt. Col. Charles Kowitz, chief of unmanned aircraft systems safety, U.S. Air Force Safety Center, citing examples from a safety assessment report requested by the FAA for the Northrop Grumman RQ-4 Global Hawk.

Assessment of 20 hazards affecting Global Hawk operations showed that risks of operating a UAS in the NAS can be more extensive and subtle than the risk of midair collisions. "If an unmanned aircraft creates deviations of altitude that unnecessarily preoccupy the attention of an air traffic controller, [that] essentially decreases the safety factor afforded to all the other participants in the NAS at the time," he said.

The main advantage of keeping a military UA inside special use airspace is the pilot's ability to fly "unfettered" compared with the constraints in the NAS, noted Lt. Col. Dallas Brooks, chief, unmanned systems integration policy, DOD Policy Board on Federal Aviation. "We have done a lot in the past to keep our major UAS operations away from heavily populated traffic areas," Brooks told the forum. "As mission needs increase, however, the pressure is on for more UAS operations and training, and it gets harder to do that. … As a last resort when we cannot use a COA … we consider, with great reluctance, a temporary flight restriction that essentially sterilizes airspace for our use."

A 2007 DOD–FAA memorandum of agreement created the opportunity to operate small military UAS in Class D airspace at about 100 DOD-controlled, non-joint-use airfields. "For small UAS — 20 lb [9 kg] or less — operations also

UAS Safety Layers Under Study for Collision Avoidance



Flight procedures	For example, under FAA visual flight rules, a magnetic course/ground track of 180–359 degrees requires flight at even thousands mean sea level (MSL) plus 500 ft if more than 3,000 ft above the surface but below 18,000 ft MSL.
ATC separation	Controllers provide route clearances, traffic information and radar vectors for aircraft separation.
ATC ground surveillance	Responses from interrogations of aircraft transponders are integrated with targets on ATC ground radar displays. ADS-B transmissions received by ATC then could be broadcast to aircraft equipped to display traffic information service–broadcast targets in the cockpit.
ADS-B	The 1090-MHz extended squitter version of this technology offers 40-nm (74-km) range in high-density environments and 90-nm (167-km) range in low-density environments.
TCAS II	Traffic advisory begins at distances as far as 40 nm; resolution advisory occurs 25–45 seconds before the closest point of approach.
Detect, sense and avoid	Technology under development would correlate and fuse inputs from DSA sensors, TCAS II and ADS-B to alert UAS pilots and enable the UA to automatically perform the appropriate collision-avoidance maneuver.

ATC = air traffic control; ADS-B = automatic dependent surveillance–broadcast; FAA = U.S. Federal Aviation Administration; DSA = detect, sense and avoid; UAS = unmanned aircraft system

Source: Northrop Grumman Integrated Systems

Figure 1

can be conducted in Class G airspace, in most cases from the surface to 1,200 ft above ground level [AGL] as long as we are over DOD-controlled lands, meaning bases and ranges," Brooks said.

Welcome to the NAS

Mont Smith, director of safety, Air Transport Association of America (ATA), told the forum, "This is a time in the history of airlines when finding methods to support the integration of UAS in the NAS — without causing delays, capacity reduction or placing current NAS users at increased risk — is of utmost importance to us." Nevertheless, ATA member airlines also have concerns — such as the risks of operating a 4.0-lb (1.8-kg) aircraft, for example, at or below 400 ft AGL in Class B or Class C airspace — because of potential proximity to an airliner that has experienced a failed engine at low altitude or is maneuvering during a required navigation performance (RNP) area navigation (RNAV) approach.

The ATA recommended that all UAS approved to operate in or near high-density traffic areas should have:

- GCS controls and displays with the "look and feel" of manned aircraft;
- Assessment of all human factors affecting the "synthetic cockpit";
- Full-motion flight simulator training for pilots of future "ultra-large payload" UAS; and,
- Synthetic vision/virtual reality display systems in the GCS that engage the attention of UAS pilots and help them maintain tactical situational awareness.

Airline Pilot and Controller Input

In May 2007, the Air Line Pilots Association, International (ALPA) adopted a policy of continued participation in FAA-industry efforts to safely integrate UAS into the NAS, said Ellis Chernoff, an airline captain and representative of the ALPA National Airspace Modernization Team.

"The end game is to have fully normalized, seamless UAS operations in the NAS," Chernoff said. "Airline pilots should not even notice that there are unmanned aircraft up there. … ATC rules must be the same regardless of the aircraft type."

Yet ALPA continues to draw industry attention to several issues:

- Standard operating procedures for in-flight emergencies vary among UAS types and operators, making it difficult for other NAS users to anticipate UA flight paths;
- Nonstandard pilot–ATC communications, such as telephone, should be acceptable only for UAS operating under a COA or special airworthiness certificate, and signal latency issues must be addressed for safety; and,
- In addition to collision risk, a UA that deviates from its assigned flight path or taxi instructions, causes an airport shutdown for an emergency landing, or strays into the approach paths of an airport could require pilots of manned aircraft to conduct a costly go-around with some increased risk involved.

All controllers need adequate UAS-related training, said Darren Gaines, air safety investigator and chairman of the Air Safety Investigations Committee, National Air Traffic Controllers Association (NATCA). NATCA's concerns include problematic assumptions about pilots' capability for visual contact; uncertainties about wake turbulence and cloud clearance; nonstandard communication methods; and incorrect use of ATC flight-following services.

"So much of what we do in ATC is visual when aircraft operate in Class B and Class C airspace or when operating visually," Gaines said. "The see-and-be-seen requirement seems to be deficient — the UAS pilots are not able to visually acquire aircraft in the vicinity, but a lot of the time, to maximize capacity, we expect [pilots] to visually acquire and follow another aircraft to a runway or to an airport, and to maintain that aircraft in sight."

UAS Manufacturer Insights

Pilot-UA interfaces have been a strong focus of attention by manufacturers, said Thomas Bachman, director, One System Common Systems Integration Team, AAI Corp. His company, for example, is working with the U.S. Army Aviation Engineering Directorate on common GCS designs for multiple types of military UAS based on a North Atlantic Treaty Organization standard for a more common architecture than used in the past, he said.

"GCSs were stove-piped — designed for a very specific UAS, built uniquely for the U.S. Department of Defense and taken into the field very quickly," Bachman said. "They were not really designed using established aircraft certification standards. Over the last four to five years, this has changed dramatically [toward designing] GCSs to the same standards as manned aircraft."

The UAS industry is seeking incremental access to the NAS over time, he said. But this will require near-term federal government funding to develop DSA; allocation of airspace other than military test ranges and NASA restricted areas as safe test areas for UAS; high priority to certification of data links and spectrum allocation for UAS;

completion of civil safety requirements and airworthiness certification standards; and a process for certifying subcomponents of UAS instead of complete systems only.

Sam Richardson, liaison to the FAA for experimental aircraft airworthiness certification and logistics program manager for the Sky Warrior/Extended Range Multi-purpose Program at General Atomics Aeronautical Systems — which manufactures the Predator UAS series — said that all variants of Predators combined had logged more than 450,000 hours by April 2008 and fly about 17,000 hours per month. Three of the company's UAS — Altair, Sky Warrior and Predator B — have military airworthiness certification by the DOD and FAA special airworthiness certification for restricted operation in the NAS, Richardson said. In April 2008, the Predator B also received FAA airworthiness certification under the agency's interim national policy.[5] "These aircraft are instrument flight rules [IFR]–capable and are currently flying IFR missions … over five continents, five oceans and many seas," Richardson said. "They are interspersed with manned aircraft coming in and out of international airports. The DOD's [UAS road map] — projecting file-and-fly capability by 2012 — is something that we really need to try to achieve rather than a 20- to 25-year process."

The Global Hawk provides an example of technologies relevant to UAS integration into the NAS, said Alfredo Ramirez, chief architect, High Altitude Long Endurance Systems Enterprise, Northrop Grumman Integrated Systems. Air Force researchers and Northrop Grumman were working as of April 2008 on flight tests of DSA systems. "Detect, sense and avoid research is well under way," he said. "The surrogate UAS — a Calspan Flight Research Group Learjet outfitted with electro-optical radar-ranging, TCAS inputs and ADS-B inputs — fuses all of this data to provide a resolution to the flight computer, so that [the autopilot] takes autonomous action, which is immediate. It is not inconceivable for this technology to be ready for use in a UAS in a matter of a couple of years. In five years, we could already be getting technical data to demonstrate its robustness."

For an enhanced version of this story, go to <www.flightsafety.org/asw/jul08/uas-forum.html>.

Notes

1. For purposes of approving UAS operations in the NAS, FAA guidance "applies only to those UAS operations affecting areas of the NAS other than active restricted, prohibited or warning areas," the FAA said. NTSB forum presenters used the term *NAS* in this context.
2. Regarding the April 25, 2006, crash of a Predator B UAS operated by U.S. Customs and Border Protection near Nogales, Arizona, the NTSB said that it "found that several factors related to pilot training and proficiency in dealing with emergency situations contributed to the accident" and identified other safety issues involving UAS equipment design and maintenance, operational contingency plans, safety risk management for UAS operation in the NAS and air traffic management of UAS.
3. NTSB's accident report on the Aug. 24, 2007, crash of a Raytheon Cobra, a small UAS, at a private airport in Whetstone, Arizona, said that the probable cause was a "student pilot's failure to follow proper procedures, specifically not verifying that the mode switch [of the manual pilot console] was in the automatic position before changing the pilot [data-link] address, which resulted in loss of aircraft control."
4. RTCA SC-203, established in October 2004, so far has published one of four planned products: *Guidance Material and Considerations for Unmanned Aircraft Systems,* issued in June 2006.
5. FAA Order 8130.34. "Airworthiness Certification of Unmanned Aircraft Systems." March 27, 2008.

The ground control station for the Predator B, like other UAS, in time will become less aircraft-specific and somewhat more like a cockpit.

U.S. National Aeronautics and Space Administration