Airworthiness certification standards for unmanned aircraft systems are a prerequisite for commercial operations in the National Airspace System (NAS). While industry-led working groups develop performance standards for command-and-control data links and sense-and-avoid systems for UAS, the FAA has taken the first step by issuing type certificates for two unmanned aircraft.

Restricted-category certificates for AeroVironment's 13-lb. Puma AE and Insitu's 44-lb. ScanEagle permit aerial surveillance in Arctic airspace, where the likelihood of encountering uncooperative aircraft is zero. Commercial flights will begin soon: the hand-launched Puma for oil-spill monitoring and wildlife observation over the Beaufort Sea; and the ScanEagle for ship-launched flights to survey ice floes and migrating whales in Arctic oil exploration areas.

“Type certification allows us to go beyond the norm, which is a UAS operating under a certificate of authorization as a public aircraft, and is the basis for commercial operations,” says Paul McDuffee, vice president of government relations and strategy for Insitu. “To the FAA’s credit, they have been willing to work with industry to come up with solutions for adopting and adapting regulations intended for manned aircraft and applying them to unmanned,” he says.

The Puma and ScanEagle were pathway programs for restricted-category certification under the FAA’s existing Federal Aviation Regulation (FAR) Part 21.25 rules. Insitu submitted its application in January, and the process went “astoundingly fast,” McDuffee says. Key was a “carve out” in FAR Part 21.25 for certification of aircraft already accepted for use by the Defense Department, which applies to both systems.

An aviation rulemaking committee chartered by the FAA in 2011 to recommend operating procedures and regulatory standards for UAS access to national airspace has submitted its plan, meanwhile. “It’s a good blueprint for how to do this,” says Scott Dann, director of strategic development at General Atomics Aeronautical Systems, noting its similarity to the Access 5 plan developed by NASA and industry in the early 2000s.

The plan proposes allowing appropriately equipped aircraft to “file and fly” above flight level (FL) 180 in Class A airspace, where separation is provided by air traffic control. “This is how it has to go—I don’t see any other way,” says Dann. In the near-term absence of a sense-and-avoid system, “those aircraft equipped to fly above FL 180 will probably have first access to the NAS.”

To fly above FL 180, aircraft will need to meet FAR Part 91 operating rules and carry a transponder with Mode S or altitude reporting, so air traffic control can maintain separation using radar skin tracks and transponder squawks. That is likely to limit access to medium-to-large aircraft. “Below 10 lb. they are unlikely to carry the equipment. Below 10 lb. they are unlikely to carry the equipment or reach the altitude,” Dann says.

Although the 2012 FAA reauthorization and defense appropriations bills have put pressure on the FAA to get activity underway by requiring integration of UAS into national airspace by September 2015, Dann says “it is impossible to do full file-and-fly by 2015 in all classes. But they could open airspace above FL 180 for properly equipped aircraft if they moved out now.”

How aircraft get to and from altitude through other classes of airspace is still an issue, but the ability to fly above FL 180 “will allow us to ferry aircraft and conduct many of the commercial ventures being considered, such as forest-fire monitoring, first responders, land-use planning—maybe even traffic surveillance if we are allowed to operate in congested airspace,” he says.

Under the proposed plan, access would work down to lower altitudes and eventually to the most-congested Class B airspace around major airports. This is likely to require UAS to carry a sense-and-avoid (SAA) system, or detect-and-avoid as it is becoming known. SAA is the combination of two functions: self-separation involving gentle maneuvers minutes from collision to stay well clear of other aircraft; and collision avoidance involving hard maneuvers seconds from impact.

Sense-and-avoid is no simple problem. Development of the algorithm for the traffic-alert and collision avoidance system (TCAS) cost $900 million and took several years, and it could be the same for SAA, says Dann. TCAS was government-developed, so industry could avoid liability for collisions. “The same has to happen with SAA,” he says, arguing algorithm and system development, testing and rulemaking involve “a decade’s worth of work that could cost over $1 billion,” although the U.S. Air Force could get there earlier.

“Detect-and-avoid is not around the corner. Ten years is a fair assessment for a civil-certified algorithm that works autonomously,” says Andy Lacher, UAS integration lead at Mitre. He also agrees that liability for the logic should rest with the government. “I would suggest it is the right way to go, but I don’t know who the decision-maker would be.”

Mitre is working with NASA Langley, University of North Dakota (UND) and Draper Laboratory to test a cooperative automatic sense-and-avoid system using automatic dependent surveillance-broadcast (ADS-B) as the sensor. The test involves flights of a NASA Cirrus SR22 surrogate UAS to test SAA algorithms developed by Draper, Mitre and UND.

“We are focused on ADS-B as the sensor because it is very accurate, with a high update rate. If the algorithm will not work with the best, it will not work with a less accurate sensor, or lower update rate,” Lacher says. “And we’re focused on an automatic algorithm. An unmanned aircraft, with loss of link, needs a capability to detect and avoid without the pilot.”

Flights last September involved simple encounters. Tests last month involved more complex and dynamic encounters, one aircraft turning or climbing into conflict with another. A final series of flights this month will look at using primary radar tracks-broadcast via the traffic information system (TIS-B). “The FAA will never accept ADS-B only. But coupled with primary TIS-B it may help in a layered approach,” Lacher says.

Ground-based sense-and-avoid (GBSAA) could find a role in terminal airspace, where ATC coordinates traffic flow but does not provide positive separation. “Airborne sense-and-avoid has to be there, but GBSAA might have to be used at dense airports where SAA could get into difficulty seeing
Fielding of an Army-developed GBSAA system will begin next year at an initial five U.S. sites where MQ-1C Gray Eagle units will be based. The system is needed “to get Gray Eagles up and away from Army airfields in national airspace and over into restricted airspace or military operating areas,” says Viva Kelley, product director for UAS airspace integration. Design of the GBSAA system was “locked down” after a demonstration at Dugway Proving Grounds, Utah, in June 2012. “We are now writing artifacts for software certification,” she says.

GBSAA uses three ground-based radars to track aircraft. Most sites require two SR Tech LSTAR three-dimensional radars in addition to the airfield’s existing ATC radar. “We have done the site surveys and have radar locations for the first two,” Kelley says. System integration will begin about a year from now, with acceptance testing at Massachusetts Institute of Technology (MIT) Lincoln Laboratory and live testing at Dugway. Initial fielding will be Block 0 capability, in which a ground-based observer recommends maneuvers based on system-generated alerts.

A Block 1 upgrade is planned that will allow the observer to recommend maneuvers generated by the system itself. Block 1 introduces collision-avoidance functionality based on the maneuver algorithms under development for the FAA’s planned ACAS-X replacement for the TCAS. “We are coordinating with the FAA . . . and our algorithms are developed from ACAS-X, which is being developed by MIT Lincoln Labs as well,” says Kelley.

The FAA is developing ACAS X as a family of collision-avoidance systems for commercial, general-aviation and unmanned aircraft flying in NextGen airspace. ACAS Xu is the variant intended for UAS, and requires a Mode S transponder, but has no interrogation capability, instead using received ADS-B messages for passive surveillance and coordination with other ACAS/TCAS-equipped aircraft.

Where TCAS works only with a transponder, ACAS Xu is designed to accept additional surveillance sources such as radar or electro-optical (EO) sensors to track non-cooperative traffic. “We are working with the FAA to integrate an early version of ACAS Xu on to the Predator B,” says Brandon Suarez, lead for sense-and-avoid activity at GA-ASI.

Flights are planned for this month or next at Edwards AFB, Calif., using a company aircraft and NASA’s Ikhana (also a Predator B) on a self-separation test that will also provide risk mitigation for a flight-test of prototype ACAS Xu logic planned with the FAA for 2014, using ADS-B to track cooperative intruders and alternative surveillance sources for non-cooperative traffic.

GA-ASI is developing an active, electronically scanned array “due regard” air-to-air radar on internal funds. “We flew a prototype on a Predator B and later this year will wrap it up into the self-separation test,” he says. “All the sensors and hardware will fly on the Predator B so we can get early maturation on surveillance and maneuvers.”

GA-ASI’s vision for self-separation is to “keep the pilot in the loop” and help them make better decisions. “Collision avoidance could be done automatically, but we would still give the pilot a chance to respond. In a situation like losing the data link, the aircraft would have to respond automatically,” Suarez says. Automatic versus pilot-in-the-loop is “still being worked on” for ACAS Xu.

ACAS Xu provides plug-and-play interfaces for radar and EO sensors. “Tracks come in in an appropriate way. Xu accepts them and uses them in the algorithm,” Suarez says. ACAS-X has separate surveillance and resolution modules (in TCAS they are intertwined, making it difficult to modify). “ACAS X can be updated more frequently for changes in airspace and operations. From an unmanned aspect, operations have changed in ways never imagined for TCAS, and this allows Xu to accommodate less-maneuverable aircraft.”

Several projects have shown the suitability of ADS-B for sense-and-avoid between cooperating aircraft. Last August in Argentia, Newfoundland, R3 Engineering (R3E) conducted what it says was the first ADS-B-based fully autonomous collision-avoidance test, followed in April by further flights at Yuma Proving Ground, Ariz., involving two L-3 TigerShark UAVs equipped with its All-Weather Sense-and-Avoid System.

The Yuma tests represented a border-patrol mission, the system using ADS-B to build a track on the intruder and-when 60-70 sec. from a collision-linking directly to the autopilot, initiating a circle maneuver to resolve the conflict, then returning control to the autopilot to continue the patrol. “You need an autonomous maneuver,” says Dick Healing, chief technology officer.

The next series of tests will involve non-cooperative traffic and R3E is working with the Navy to integrate ground primary-radar data into the system in the same way as ADS-B, to provide a non-cooperative capability without onboard radar. “We want to compare the accuracy of ADS-B to data derived from radar,” Healing says.

“Can we use ADS-B data for sense-and-avoid? Definitively. It provides excellent data on where you are and where you are headed,” says Mark Askelson, principal investigator at UND for the project with Mitre, NASA and Draper. “We can have EO or radar capability and ADS-B as well. We are going to need redundancy in sense-and-avoid.”

“We need to do experimentation and get data to look at. Our main purpose is to conduct simulation and flight tests to generate data for the standards committee to consider,” says Lacher. “Also we recognize any solution will need to be evaluated and we need a capability for that. Mitre in partnership with NASA Langley is developing a simulation-to-flight framework to evaluate algorithms in simulation, then in flight. This is needed by the community to make a safety determination.”