The Future of Unmanned Flight

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Just five years ago, the idea of the futuristic aircraft known as Unmanned Aircraft Systems (UAS) dotting our skies seemed more like talk of UFO sightings than future tech, but now, “I think you’ve got to be pretty deluded to think that we’re not going to have unmanned aircraft in the National Airspace,” says Craig Woolsey, director of the Virginia Center for Autonomous Systems and a Virginia Tech research professor.

According to the Association for Unmanned Vehicle Systems International (AUVSI), these futuristic UAS often seen as a privacy threat will create $82 billion in economic impact over the 10-year span from 2015 to 2025. In response, savvy avionics companies have already created Unmanned Aerial Vehicle (UAV) control, guidance and navigation micro-avionics systems that can fit into often small, lighter-than 5-pound systems.

According to Dallas Brooks, director of consulting company UAS ONE and an AUVSI board member, “The best thing about UAS technology is that everything we do makes the rest of aviation better. … If you have an auto control system that you can shrink to the size of a matchbox, it’s now affordable for a General Aviation [GA] pilot who could never have an autopilot before,” says Brooks. UAS use has already expanded beyond Border Patrol and military drone strikes. At Kansas State University, UAS Program Manager Mark Blanks works with “rock-stable” mounted gimbaled cameras that capture pristine video while suspended in gusts. Researchers like Woolsey, also associate professor and assistant department head of the Virginia Tech Aerospace and Ocean Engineering Department, employ UAV sensors that can comb the air for pathogen spores and even detect concentrations for substances like anthrax via in-flight micro-chemical lab processes.

That sampling of research underway at Virginia Tech and Kansas State programs represent only a fraction of international applications. In the United Kingdom, where the Civil Aviation Authority (CAA) has already regulated and legalized limited use of commercial UAS operations, a small startup called Quest UAV has completed work with the European Space Agency to land UAVs in the rugged mountains of Chile and with the British Antarctic Survey to land UAVs on glaciers in the South Pole.

The startup, which primarily uses payload sensors to capture digital elevation models and 3-D ground maps, is also working on cameras that can capture thermal infrared data for agricultural and forestry usages. Brad Hayden, the former vice president of marketing at Aspen Avionics and now director and founder of Robotic Skies, is anxious to see the United States enter the commercial UAV market. Hayden launched Robotic Skies to disseminate future FAA UAV standards to Fixed Base Operators (FBO), Maintenance Repair and Operations (MRO) shops and Part 145 Repair Stations and to act as a liaison with regulators. As an umbrella organization, Hayden and Robotic Skies will help current aviation repair shops add UAV upkeep to their repertoire, which in turn Hayden hopes will give the FAA confidence that the U.S. really is ready for airspace integration of UAVs.

"In my mind, the future of flight is really going to be rooted in the integration of the emerging commercial drone market and the current aviation support infrastructure," says Hayden, who has also created a UAV education and community site called Droneport, which will ultimately help define what future airports look like through serving as a social industry platform facilitating discussion.

Developments in GPS, camera and accelerometer products, driven by smart phone market growth, mean the technology is ready to cash-in on those AUVSI numbers, but the FAA has not released safety standards and requirements for UAS. Those regulations are due by 2015 as called upon by Congress in the FAA Reauthorization Act of 2012, after three-plus years of delays; meanwhile, operators and hobbyists are very anxious to see the first wave of regulations for UAS weighing less than 55 pounds. "There is no denying that the regulations are holding us back," says Hayden. "At the moment, the people that you have flying commercially are, in effect, flying in the face of the FARs [Federal Aviation Regulations]. … were some type of guidance in place, the majority of operators would follow them."

Meanwhile, large commercial operators Insitu and AeroVironment have received restricted category type certificates from the FAA allowing limited commercial operations, which Insitu launched last summer on the north shore of Alaska in work with an oil exploration company. AeroVironment has confirmed their system is operating with an unnamed customer as well, and AeroVironment does have international commercial UAV projects in the works, according to Steven Gitlin, vice president of marketing strategy and communications. Charlie Guthrie, Insitu's senior vice president and CTO, says they have been at work with the states of Washington and Oregon on fire fighting and surveillance while Gitlin says the U.S. Geological Survey and the Department of the Interior have used AeroVironment's Raven system to monitor wildlife. But even with the commercial endeavors ventured, Gitlin says regulations have prevented AeroVironment from benefiting "enterprises, taxpayers and other government organizations." In response to outcries from industry experts that the U.S. is lagging in the international market, Fairfax, Va.-based consultant Teal Group projects industry sales from 2014 onward will total to $89 billion by 2023, yet the U.S. has not even entered that market commercially. Brooks and Blanks agree that the FAA could do more. "Some folks would say

we've fallen behind Australia, for example, which has a more relaxed regulatory environment for UAS, or Canada, which allows [UAS] commercial operations," Brooks says. "There are certainly leaps that I think both Mark [Blanks] and I feel we could make tomorrow within our current regulatory systems without a huge impact … but we must ensure that our systems can demonstrate a reasonable level of airworthiness."

UAV capability to "sense and avoid" is one major, as-yet undeveloped technology that Hayden calls "the holy grail of UAVs," and Blanks, Brooks, Guthrie and Woolsey agree it is a key factor to full NAS integration. Though there have been attempts and flight tests demonstrating instances of successful sense and avoid, Woolsey says there has been no definitive answer. "I'm not convinced and the FAA is certainly not convinced that [any demonstration] has solved the see and avoid or the sense and avoid problem," he says.

A large part of the reason all tests have fallen short, according to Brooks, is the lack of any published performance standards. "Without a defined standard that says you need to miss by this much or this distance or this amount of time, it's difficult to commit billions of dollars to research, only to find out that your answer may not have been good enough," he says. In the U.K., the CAA has not come out with any sense and avoid standards either. "We basically are waiting for the industry to present, first of all, the standard and then the technology," says King.

The military has been working to develop sense and avoid since as early as 2009, according to the Air Force's Unmanned Aircraft Systems Flight Plan, which states that "a significant amount of FAA resources are being used to work collaboratively with DoD in the development of sense and avoid capability and system safety levels." The Remotely Piloted Aircraft Vector 2013-2038, or the "RPA Vector," meant to replace that 2009 report, confirms that the Air Force is still working with the FAA to develop material solutions for collision avoidance. Colonel Kenneth Callahan, the Air Force's director for Remotely Piloted Aircraft (RPA) Capabilities, says key Air Force priorities highlighted in the RPA Vector are access to the NAS, safe flight, and airborne sense and avoid, which he says the Air Force would like to have resolved in the near term. Woolsey thinks viable solutions should surface within two to five years, but tech developments can't help UAVs go commercial without FAA approval. Some speculated Automatic Dependent Surveillance-Broadcast (ADS-B) radar technology would be a partial solution, but exemptions for gliders, ultra lights and other aircraft meant too many "invisible" aircraft UAVs would be unable to sense and avoid obstacles.

Autonomous Flight?

Once a sense and avoid solution does gain FAA and other civil aviation authorities' approval, UAV commercial applications not only become viable in different altitudes and locations, but the controversial autonomous system also becomes possible.

"The FAA is not excited about autonomous aircraft," says Woolsey, but Callahan says the Air Force is interested in technologies that will make them more autonomous. Currently, the Air

Force has personnel tasked to remotely pilot the aircraft. Autonomous systems would free up resources and enable other operations because, according to Callahan, “it demands less effort from people, really, or one person can fly two.” But the Air Force will not even be fully manned and equipped for RPA until the end of fiscal year 2019, he says. Such a major drain on military resources makes it “a big line on our roadmap,” Callahan says.

But even bigger than the sense and avoid question, says Woolsey, is regulation, which will remain a roadblock long after the technology has advanced. He thinks both science and regulation questions could be answered, however, within 20 years. Sense and avoid and autonomy together in turn create a need for more robust, aggressive systems, which Woolsey has already seen under development. However, Blanks says the technology is not all developed yet. Sensors, data processing, machine learning, assured communication and modularity all need development. Callahan asks, “how do I reach back a couple iterations or upgrades to actually talk to someone at a lower level that may not have the newest version of software or hardware that I have?” The Air Force also wants “modularity,” meaning sensors can be easily swapped out to aid customers who want to use their UAV for more than one purpose or, in the case of the military, to ensure mission capability.

Hyper and multi spectral imaging present further development opportunity, in which use of multiple cameras or sensors allow data collection on several regions of the electromagnetic spectrum. Quest UAV has already launched multispectral operations but King feels laser radar, or “lidar,” needs further development for multispectral use. Yet another issue needing development is spectral management and allocation. Operators need to be able to talk to the aircraft, whether it is autonomous or manned. “If you had 10,000 or 50,000 of these aircraft flying on the same band of free radio frequency, are they going to step on each other? Are we going to have enough room for it? Is it going to be protected spectrum?” Blanks asks. He cites that the 2012 World Radiocommunication Conference allocated spectrum for UAS use only, but he is uncertain about the parameters and adequacy.

“If you lose link with the aircraft, it’s going to do some hopefully autonomous maneuver, it’ll come back home, land automatically or whatnot; but first of all you need to guarantee it’s always going to do that. … That has not matured to the point of saying it’s safe enough for unrestricted access to the National Airspace [System],” says Blanks.

The UAS Crystal Ball

Cities will be the last place we see UAVs, because of regulatory constraints, Guthrie says. He doesn’t expect to see UAVs in populated areas for several years. Class G airspace, from the ground to 1,200 feet, will be the first airspace to see legal commercial UAVs, according to Brooks. Hayden thinks it will be a subset of Class G, under 400 feet specifically, with certification established via a simple airworthiness check. Woolsey thinks the U.S. commercial market will open before sense and avoid arrives, with line-of-site observers and a two-person-per-UAV requirement as the way around risk of collision.

Regardless of the particulars, most experts agree that initial applications will be in agriculture. The rural, unpopulated environment and the fact that it's a huge driver of the GDP support that supposition. Other uses, such as fire monitoring, search and rescue, and post-disaster assessment might follow, says Woolsey, for the same reasons.

The next wave of integrated air space will be 63,000 feet and up Instrument Flight Rules (IFR), Hayden guesses. "There's nothing up there that they can really bother, at that altitude," he says. John VanBrabant of Northrop Grumman notes UAVs can already do that and that it would be safe, but it's the "spiraling up and down" that's the problem.

"The real tough integration is going to be in the middle," says Hayden. "Everything 500 feet all the way up through the flight levels. That's going to be the tougher area. … Personally, again though, I believe that the technology will be developed to allow them to integrate, not by 2015, but potentially within the next few years."