the AUTOMATION end game

How cockpit autonomy will change flying forever

by Stephen Pope

Humans beware. Computers want your job, and considering that they're smarter, better looking and will work for no pay, they'll probably get it someday. For professional pilots that could mean preparing for the day when the captain is a software app and you're just along for the ride.

In the same way that improvements in computing technology eliminated the need for a flight engineer acting as a dedicated third crewmember aboard earlier-generation airliners, an increased reliance on cockpit automation could eventually make the two-pilot flight crew a relic of a bygone era as well.

Aerospace technologists dream of a world in which fully automated aircraft will be allowed to operate gate to gate or ramp to ramp with minimal interaction from the pilots, whose primary jobs will be to monitor systems and intercede in case of emergency. These future aviators could perform their duties from the ground, experts say, making it unnecessary–at least conceptually–to fly with a two-pilot crew or with any pilots at all.

"You can imagine a time when we'll have one pilot who is fully familiar with the 'aviate' functions of the aircraft and a second crewmember who is more of a systems manager," said Bob Ellis, director of product and systems marketing for Rockwell Collins in Cedar Rapids, Iowa. "In such a scenario you'd need to have a sophisticated electronic automation function that performs all of the secondary aviator functions that a second pilot does today. Eventually we could allow automation to take over the secondary functions, leaving just a single pilot in the cockpit."

Taking this idea a step further, researchers are beginning to explore ideas for fully autonomous civil aircraft that would operate similarly to military unmanned aerial vehicles (UAV).

These days, the idea of pilotless airplanes is nothing startling, of course. UAVs seemingly come in as many shapes, sizes and configurations as developers can envision. Boeing and Gulfstream have even presented a design for a high-altitude, self-flying spy plane based on the G550. FedEx and UPS, meanwhile, are asking aircraft manufacturers to study the feasibility of producing unmanned aircraft for their freight-hauling operations.

Some even see a day when airlines will shuttle passengers among destinations with only a "systems minder" present on the flight deck, whose role would be analogous to that of the engineer on autonomous light rail transit systems.

Sound far-fetched? It's not pie in the sky to many of the people who are being tasked with creating the NextGen operating environment and the future ground, space and onboard systems that could well make autonomous flight a routine part of our daily existences.

"It's kind of hard for me to imagine why we wouldn't use unmanned vehicles 10 or 20 years from now to carry cargo if the infrastructure allowed us to move aircraft safely without a pilot," said Bob Witwer, vice president of advanced technology for Honeywell Aerospace. "The most important aspect of UAVs interacting in the NextGen environment is how we deal with them from a control point of view, which I think has a direct impact on where the future of cockpit automation is headed."

But again, an initial step before we rid airplanes of onboard aircrew would likely involve adjusting the duties of a two-pilot crew by assigning one crewmember the task of manipulating the controls and the other with functions related to automation management. This concept could give way to single-pilot cockpits where the human on board merely monitors the systems and makes inputs only when needed. The human pilot would also have the ability to take over the flight controls to avert disaster, but otherwise he would stay out of the way.

The Pilot Shortage Averted?

Further in the future, researchers think fully autonomous aircraft could be flown not only in cargo operations but perhaps also for passenger transport. A designated pilot or air traffic controller based on the ground could be assigned the task of monitoring onboard systems and interacting with the aircraft via secure datalink, as happens now with many military UAVs. Such a setup would certainly go a long way toward solving the looming pilot shortage forecasters are predicting.

"The interoperation of unmanned aerial vehicles in the NAS airspace is beginning to explore the questions about how we could manage remotely piloted aircraft," Ellis said. "This is a field of automation that you could imagine seeing on a roadmap at some time in the future, probably in the cargo airline environment first and then migrating to the concept of 'less piloted' airplanes leading to a considerable increase in the level of automation."

Whether a passenger would accept a seat aboard an airplane without human pilots up front is a major question, but researchers don't view this presumed anxiety as the insurmountable hurdle some might think. Today's travelers would undoubtedly balk at the idea, but if autonomous aircraft someday can be flown as safely as human-piloted airliners and business jets, researchers argue, there is no reason why tomorrow's air travelers should have any qualms about strapping into their seat knowing a computer and not a human is doing the flying. "After all, how much of the actual manipulation of the controls are pilots responsible for today? Not much," Ellis observed.

It won't happen overnight, experts say, but there could come a day when passengers step aboard an airplane that doesn't even have a cockpit.

"I see several stages that aircraft will go through to reach that point," Honeywell's Witwer said. "We've got two-pilot aircraft now versus the three-man crews we had when the flight engineer was on board. People accepted that change. The idea of a pilot going away and leaving a single pilot on board is disturbing for many. But we could start with two pilots where the functional allocation of tasks is really on one pilot and the other is like a 'hot spare.' That way we could make sure that the workload for what would ultimately become a single-pilot or even a no-pilot environment was viable."

Aviation consultants say they cannot imagine the government or the public accepting pilotless commercial airline travel–even though computers have taken over large pieces of pilots' tasks. But autonomous airplanes are becoming progressively better at takeoff and landing, and the idea of pilotless FedEx and UPS transoceanic flights is technically plausible, even many skeptics admit. Still, it's hard to imagine autonomous aircraft handling emergencies anywhere near as well as humans, the most recent famous example being Capt. Sully's Hudson River splashdown last winter.

Once the confidence in the automation reaches a point that

the aircraft can be flown safely with a single pilot, the operation would probably be classified as fully automated with the lone remaining pilot merely acting as a backup to the flight computers, Witwer predicted. "You could imagine a day when air traffic control could have someone who was a fully skilled remote pilot on call and ready to intervene if there was an emergency in which a single pilot in the air was no longer capable of piloting the aircraft," he added. "That could be a workable solution."

NextGen the Technology Driver

Of course, there are still far more questions than answers when it comes to integrating autonomous aircraft with regular air traffic, let alone unleashing entire fleets of UAVs in civil airspace. But the introduction of NextGen technologies such as automatic dependent surveillance-broadcast (ADS-B), 4-D navigation, required navigation performance (RNP) and datalink communications coupled with decision support aids and collaborative decision-making tools will lay the ground work not only for greatly improved operating efficiency and safety but also for semi-autonomous and fully autonomous flight operations. It's more a matter of when and not if, experts say.

"A high level of flight-path automation is fielded today in the Department of Defense environments with UAVs," said Ellis. "When the decision-support tools evolve to the point where you could view the onboard computer as a true pilot assistant, then I think automation in terms of the entire flight-management function will become feasible." Airlines love the idea of single-pilot operations for the cost savings.

The goal of NextGen is to allow air traffic to fly in a more predictable manner and with greater efficiency by combining a host of information about aircraft, weather and airspace using onboard sensors, enhanced situational awareness tools and trajectory-conflict resolution techniques to manage ever more aircraft in the same airspace while reducing delays, saving fuel and cutting emissions.

The introduction of required time of arrival operations coupled with expanded ADS-B IN (receive) and OUT (transmit) capability to include not just aircraft state data but all of the information about an aircraft's trajectory shared among all other aircraft and controllers will create the framework for mixing unmanned and "more autonomous" aircraft with fully crewed aircraft. The major obstacle for infrastructure and avionics designers in a post-NextGen operating regime will be in developing the appropriate decision aids for managing autonomous aircraft. A key ingredient will be creating the data network and faster delivery pipelines to support the sharing of vast amounts of information. Satellites could provide this function, but securing them from attack by terrorists of hackers would be vital.

Making such an enormous technology leap won't be easy and it can't happen overnight, researchers concede. The FAA is introducing the concept of "best-equipped, best-served" to allow more capable aircraft to incorporate the latest NextGen technologies while still integrating with older airplanes that have only some NextGen capabilities. Unlike the mandate for reduced vertical separation minimums, which required all aircraft in a given block of airspace to be equipped exactly the same way, NextGen will allow aircraft of disparate technological capability to mix seamlessly. Aircraft that have the full complement of NextGen capabilities will be given priority handling while less well equipped aircraft will in essence become second-class citizens. This isn't an ideal situation for operators of older aircraft, but it's more realistic than requiring all aircraft old and new to meet the same level of operability by a given date.

Whether you believe the days of the two-pilot professional flight crew are numbered, there's no denying that the technology behind autonomous operations can offer safety benefits. For example, autoland capability combined with the use of adaptive flight controls and damage/fault tolerance sensing could lead to the introduction of "panic" buttons on business jets that would enable the crew or a passenger to direct the airplane to land itself at the nearest suitable airport in case of a birdstrike, midair, pilot incapacitation or other emergency. When the panic button is pressed the airplane would automatically input a flight plan, contact ATC with its intentions and fly to the nearest airport for landing. Some researchers have even considered technology that would let ATC take control of an aircraft in the event of a hijacking.

Operating in NextGen airspace will require far higher levels of cockpit automation than exist today. Flying curved paths that have extremely tight airspace and time boundaries while maintaining so-called "bubbles of protection" will make automation necessary.

Fully autonomous flight operations are already occurring regularly on the battlefield, and it's only a matter of time before UAVs are commonplace in civil airspace as well.

The Benefits of Automation

Flight-deck automation has been a part of aviation for decades. It really started in the 1940s with the advent of the first true autopilots (we're not counting the "automatic pilot" Lawrence Sperry devised in 1912) and continued through the years with the introduction of automated crew alerting systems, flight management systems, autoland capability and fly-by-wire. Today the job of the pilots is more about trajectory management than manipulation of the control surfaces. In fact, in fly-by-wire airplanes the pilots have no direct mechanical link to the control surfaces.

In the future even more of the systems on board the aircraft will benefit from automation. Weather radar is one example of where safety can be improved by having the onboard computers take over duties that are now the purview of the pilots.

Today onboard weather radar senses the weather and presents an image to the pilot. The pilot interprets that image and decides what action to take. A large storm cell ahead could mean deviating from the intended track to remain clear of turbulence. How much of a deviation is needed is entirely up to the crew, but in the future the flight management system will have a say as well.

"We clearly see a future where there is an automation function running in the background that looks at radar data not just as a sensor image but as a weather object," Ellis explained. "The aircraft network will be able to interpret the information and present to the flight crew a picture of the weather as well as a pre-planned potential alternate flight route."

Adding an element of automation to tactical decision-making will reduce flight time and save fuel by allowing the aircraft to skirt storms by no wider a margin than is necessary. The trick to making the concept work will be ensuring there is an extremely low error rate and low false-alarm rate. Because today's onboard radar produces video images and not information about the weather, developers need to change the way these systems operate. "But we think this technology can be commonplace in the cockpit by 2020," Ellis predicts.

ADS-B is another technology that is well placed to provide

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Time Flies Like a Fourth Dimension

One of the requirements emerging from NextGen is 4-D operations, where the fourth dimension is the time element. The FAA wants aircraft to be able to hit a point in space using required time of arrival (RTA) tools with a margin of plus or minus six seconds. Meeting such tight tolerances will involve close integration of the flight-management system and autothrottles. The requirement for 4-D navigation will be one of the first NextGen technologies pilots experience.

"Existing flight-management systems can be upgraded through software to meet the RTA requirements," noted Dan Reida, vice president of marketing for Universal Avionics in Tucson, Ariz. "We see the initial implementation of 4-D operations happening within five years."

A big question when considering 4-D operations is what to do about airplanes that don't have autothrottles and can be upgraded only with expensive modifications. It would be possible to achieve some level of RTA functionality with manual cues that the pilots control with the thrust levers, but obviously 4-D navigation is an area where automation excels. An RTA window that is only seconds wide, in fact, probably could not be managed manually. If the FAA allows certain airplanes to meet RTA thresholds that are measured in minutes, manual control would not be much of an issue, although it would probably still increase pilot workload.

"I'd be a promoter of the more minimalistic approach to allow us to start using the technology without the expense related to automation of the RTA element," Reida said. "Newer aircraft, of course, are going to have some sort of power-management capability, but we don't want to force legacy aircraft out of the system."

Controller-pilot datalink communication (CPDLC) is another area where automation can play a role. Aircraft today are sending and receiving datalink messages to controllers and dispatchers, which is making the cockpit a far quieter working environment. In the future, controllers, dispatchers and third-party service providers will be able to beam flight plans directly to the FMS, which the pilots would accept with a simple button push.

If the ultimate vision for autonomous flight operations is indeed realized, perhaps the pilot wouldn't even have to take that step. – *S.P.*

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additional safety and efficiency benefits when combined with automation tools. The targets that ADS-B tracks aren't just an image the pilots see on the flight display showing proximate bearing and distance. Rather, ADS-B traffic targets come with a wealth of object data, including the identity of the target, its size, current position, direction of movement, velocity and intent. A real-time database and ADS-B in software applications running in the background can track up to 440 targets and create a bubble of protection that the onboard automation could use to stay well clear of other traffic.

Safety will be a key driver behind the introduction of future automated warnings. The FAA is interested in creating better collision-avoidance tools for use on the airport surface. Current systems, such as Honeywell's runway awareness and advisory system and the FAA's airport surface detection equipment (Asde-X), will be combined with new decision-support aids in the form of warning systems that look at all ADS-B traffic, including ground vehicles. Here again, the false-warning rate will be the biggest hurdle in developing an automated system that can issue ground traffic conflict alerts in real time.

Researchers think cockpit automation will make it feasible one day to operate transport-category jets single pilot.

Merging and Spacing

ADS-B also holds the promise of greatly increasing airspace capacity by feeding more airplanes into airports at tighter spacing intervals. So far the FAA has been looking at specific operator instances where ADS-B can provide efficiency benefits. The early model has been the work done by UPS at its Louisville, Ky., cargo hub. UPS was the launch customer for the SafeRoute suite of ADS-B in applications from Aviation Communications and Surveillance Systems, a joint L-3 Avionics and Thales company.

UPS has fitted several Boeing 757s and 767s with technology that includes cockpit display of traffic information (CDTI); surface area movement management (Samm), merging and spacing (M&S) and CDTI-assisted visual separation (CAVS). Samm displays airborne and ground traffic in the terminal area on an airport moving map, while M&S optimizes runway capacity by allowing pilots to achieve and maintain a specified time interval between arriving aircraft.

Crews flying with the ADS-B tools have been able to reduce the fuel they burn by flying more precise continuous descent approaches. Still, pilots don't feel entirely comfortable flying at the reduced spacing intervals. Researchers think increased reliance on automation could be the key to unlocking the full potential of such tools.

Whether or not cockpit automation increases to the level researchers hope, it is clear that the introduction of NextGen technologies and the refinement of the automation that already exists will provide measurable safety and efficiency benefits. ❑