The brave new world might someday move pilots out of the cockpit

Technology is marching ever onward, and it sometimes seems as though we are intent on eliminating all human involvement in complex operations—including flying airplanes. Who among us has not wondered, after some accidents that have happened, whether a properly programmed computer might have done a better job of flying the airplane?

The downward trend in the number of pilots in cockpits over the past decades seems to support that conclusion, too. Better technology directly eliminated the flight engineer position, and the two-pilot cockpit is completely normal now for the largest airplanes. Even one-pilot cockpits are ordinary, both in simple aircraft and in business jets that are fairly complex, from the lightest of Part 23 jets such as the Eclipse 500/550 to the Part 25-certified Citation 500/560 operating under a single-pilot exemption.

So the industry has already made the shift from two- to one-pilot cockpits. Are further reductions possible? Could the two-pilot flight deck of the airlines be shrunk further to one pilot? And what about the ultimate technological goal: a no-pilot passenger- or cargo-carrying aircraft? Is that where aviation is headed? Other industries are already tackling this problem, from driverless Google cars to Canadian oil-extraction companies looking to eliminate truck drivers. Travelers to Dubai who have sampled the city-state’s Metro system might be surprised to learn that it covers 47 miles of tracks without train operators (although wardens travel on trains to help with emergencies).

Aviation research is headed in this direction. The National Aeronautics and Space Administration’s Safe Autonomous Systems Operations (SASO) project has as its goal “to seek ways to safely integrate within the National Airspace System the highest level of automation that is justifiable, but not to explore automation simply for automation’s sake.” NASA envisions a far more autonomous future when the FAA’s NextGen redesign of the National Airspace System is fully implemented.

The Defense Advanced Research Projects Agency (Darpa) has signed contracts...
with three companies for re-
search into an Aircrew Labor
In-Cockpit Automation Sys-
tem (Alias). While some writ-
ers have characterized Alias
as a flying robot copilot that
gets plopped into one of the
cockpit seats, that’s not ex-
actly accurate. Alias, according
to Darpa, is “a tailorable, drop-
in, removable kit that would
enable high levels of automa-
tion in existing aircraft and fa-
cilitate reduced need for on-
board crew.”

Phase 1 of Alias involves
developing “minimally inva-
sive interfaces” between today’s
aircraft and automation sys-
tems that would be in the form
of a “drop-in, removable kit.”
This does not envision a beep-
ing, blorping Star Wars R2D2
strapped into the right seat.
The drop-in kit would be able
to work in a variety of aircraft
and relieve the pilot of having
to provide “constant vigilance
over lower-level flight mainte-
nance tasks.”

According to Darpa, “The
program intends to leverage the
considerable advances that have
been made in aircraft automa-
tion systems over the past 50
years, as well as the advances
that have been made in remotely
piloted aircraft technologies,
to help shift and refocus pilot
workloads, augment mission
performance and improve air-
craft safety.” The three com-
panies working on Alias are
Aurora Flight Sciences, Lock-
heed Martin and Sikorsky.

The primary arbiters of the
interface between pilots and aircraft
remain avionics manufacturers,
although airframe manufacturers
influence these design decisions,
too, because it is their money that
pays for the avionics.

To find out where avionics
design is headed in view of
these trends, AIN interviewed
four manufacturers of today’s
highly integrated avionics to
find out whether they are work-
ing on technology that would
reduce or eliminate pilot posi-
tions and what it would take to
achieve that goal.

Rest assured, however,
pilots are not going to lose
their jobs in the near- and
medium-term future. This is
not just because the technol-
yogy isn’t quite there yet but
also because passengers still
want someone up front in the
airplane who has a stake in
the outcome, and not a remote
operator guiding their fate
from an office building.

There is no question that
a convergence of technologi-
cal capability is taking place.
Unmanned aircraft of all types
are growing in proficiency, in
exponential leaps and bounds.
And there is a tangible problem
in developing enough pilots to
fill the needs of unmanned air-
craft systems (UAS) operators
all over the world.

Perhaps someday this will
result in large no-pilot air-
craft, maybe starting with
cargo carriers. In an age when
self-driving cars are already
plying public roads and when
in our lifetimes we may relin-
quish ordinary driving duties,
this may not necessarily come
as much too much of a surprise.

Rockwell Collins
Studies Feasibility

Last year NASA’s Ames
Research Center signed a four-
year contract with Rockwell
Collins to study single-pilot
operations (SPO). This is not a
new concept; NASA’s Flight
Deck Display Research Lab
held a meeting in 2012 to dis-
cuss SPO, and it was attended
by aircraft manufacturers (Boe-
ing, Cessna, Eclipse), avionics
manufacturers (GE, Honey-
well, Rockwell Collins), United
Airlines and university and gov-
ernment representatives.

The goal of the Rockwell
Collins SPO contract, still in
its first year, according to Mike
Matessa, senior systems engi-
eer at the Rockwell Collins
Advanced Technology Center,
“is to explore the feasibility of
single-pilot and reduced-crew
operations. We’re looking at
concepts and technologies
that would enable [this], and
any gotchas.”

One technology that is hav-
ing a big influence on this
work is airborne connectivity,
according to Geoffrey Shapiro,
also a senior systems engineer
working with Matessa at the
Advanced Technology Center.
“A cornerstone of making this
work is a robust ground net-
work to help pilots in the air,”
he explained. “We’ve had the
capability of autolanding for
a while. We’re taking that a few
steps further.”

However, he added, the sys-
tem wouldn’t depend on even
a low-bandwidth connection,
although broadband connec-
tivity would be optimal. “We
know that connectivity will fail; that is inevitable. But
there are safeguards in place
to make sure that it is safer
than current operations.”

The initial concept that
Matessa and Shapiro are eval-
uating includes a sole pilot
in the cockpit supplemented
by a “super dispatcher” on
the ground. This dispatcher
would monitor multiple air-
craft, but if a pilot needed
piloting assistance, the dis-
patcher could call in a remote
second pilot to help out.

One requirement to make
this concept work would be
physiological monitoring of
the pilot in the air. This would
make sense in a setup where
only two pilots are flying, say,
a long-distance trip, and SPO
is used while one pilot rests.
“If the pilot has a heart attack,
we need to know that,” Shapiro
said. “Do we need to bring the
other crew up there?”

This isn’t just about mon-
toring pilots to make sure they
are alive and healthy. “Automat-
ion monitoring requires that
pilots engage with the system,”
he added. “It’s critical to know
that the pilot is engaged with
the automation and has proper
situational awareness. This is
critical technology that has to
be mastered.”

For example, what technol-
yogy would facilitate commu-
nication between a sole pilot
and the super dispatcher or
ground-based pilot? After all,
Matessa pointed out, profes-
sional pilots still have prob-
lems communicating with the
pilot a few feet away. “We’re
starting to add enabling tech-
nology like video and shared
documents and indicators of
activity, and it’s definitely help-
ing their ability to understand
what the other person is doing.
Even separated, they are able
to complete tasks but give bet-
ter ratings about how they feel
they performed.”

The Rockwell Collins work
involves simulation of SPO
and exploring various scenar-
ios, such as figuring out how
SPO can handle systems fail-
ures on the airplane, an airport
closing because of weather,
reroutes and so on. “It looks
encouraging,” Shapiro said,
“and is definitely worthy of
continued study. We don’t see
any showstoppers yet.”

Although this research isn’t
focused on a no-pilot cockpit,
it will have to consider incapaci-
tation of the sole pilot. “The
ability to do an automated
landing at the nearest airport
is an essential concept for safety,
and it would feed into this,”
Matessa said.

“The important element
is to know what humans are
good at and what automation
is good at, and striking the
right balance,” Shapiro said.
“Humans are fantastic deci-
sion makers. You don’t want
to turn this all over to auto-
mation. Humans are a great
check against computers, to
make sure they’re doing what
they’re supposed to be doing.
Computers are great monitors.
“A hybrid approach takes advantage of what machines and humans are good at. Basic piloting skills are not going away. We’re not saying that folks [should not be] hand flying and are not required to have basic airmanship, no way. The pilot role may be changing a little bit, but it’s not changing as much as you would think.”

**Honeywell Looks to Human-Machine Interface**

“I’m not a big fan of the idea of non-piloted aircraft,” said Bob Witwer, Honeywell vice president of advanced technology. “I don’t know that there is such a thing or will be for a long time. Just like anything else that we do when we’re doing aerospace design, what are the mission needs? We really need to understand the mission.”

In Witwer’s opinion, the focus should be less on reducing the number of pilots in a cockpit and more on human-machine collaboration.

Historically, he sees the drop from three to two pilots coinciding with the advent of the flight management system (FMS). At the other end of the spectrum is a modern UAS, which replaces the airborne pilot with a machine and fuel that enables a much longer and more far-reaching mission.

In the air transportation arena where carrying humans is the mission, he sees passengers being hesitant about any further reduction in cockpit crew members. Even with one pilot, he explained, “we need to have the vehicle be fully autonomous. It needs to be fully non-pilot-resident capable,” with assistance available from the ground. “You’re only one heartbeat away [from disaster]. The only difference between two and one pilot is how often you have to invoke the no-pilot part. This isn’t about eliminating humans. One way or another humans will be involved in mission management.”

At its most fundamental level, Witwer sees this technology playing out as a way for the pilot and the machine to operate “hand in glove,” collaboratively. “Think Luke Skywalker and R2D2. When humans and machines can interact in that way, it’s better than a fully automated or fully human-based system. Humans and computers are each better at a lot of things. How to mesh them together is our focus. If it leads to greater levels of crew reduction, that could well work. But there can’t be any degradation at all in safety. If it doesn’t drive better safety, whatever crew configuration we’re at, then it hasn’t been a step forward.”

Two technological developments mesh with the future Witwer envisions. One is faster and more reliable airborne connectivity, such that aircraft are always online and become part of a node in a network. More important, he added, is “the ubiquitous use of [portable] computing devices in the cockpit.”

Until relatively recently, it was a given that all of the technological capability had to be resident on the aircraft—in the FMS, for example. But that attitude is changing, and where certification is not required, portable devices are taking on increasingly important roles. It will be important for avionics designers to consider how to “provide superb human-machine capability” with these new devices, he suggested.

This could further develop into the use of expert systems, either installed on portable devices or even available from the ground, given good enough connectivity, he said, “crunching all kinds of data in the background, so it’s always sitting at the ready to provide pilots with guidance. It might even anticipate that and detect the pilot’s profile and give him what he needs when.”

Witwer imagines a portable device on which a pilot could practice an instrument approach while in cruise. “From my point of view, those kinds of capability end up, at a minimum, helping
us go down this path of better human-machine capability and collaboration.”

He isn’t keen on the idea of eliminating pilots entirely because there are too many ways technology can fail, stemming either from fundamental design issues that didn’t consider all the vulnerabilities of a system or from intentional attacks on the system. One example is the Germanwings crash, where a suicidal pilot decided to lock his colleague out of the cockpit. This was clearly not something that designers considered when cockpit doors were secured against terrorist attacks. “Any time humans are involved it’s virtually impossible to prevent the one-in-a-million [event where someone] does something they shouldn’t,” he said.

“Therein lies one of the big concerns,” Witwer added, “about going to full automation and getting humans out of the loop: making sure you have super-high levels of availability and integrity of all the systems, and that nobody can monkey around with them. If you rely on connectivity with onboard automated systems, then you have to deal with the question of malicious and nonmalicious problems.”

He cited as one example of an unforeseen malicious problem the fire that closed the Chicago en route control center in September last year, which caused huge problems managing the center’s airspace. “I bet a lot of people were happy those airplanes had pilots flying them,” he said.

For pilots who are flying now, there has been a subtle transition that is helping them do their jobs with greater safety and efficiency. Traditionally, pilots had one display for tactical information (nav displays, 2-D moving maps). “There was a hard line between tactical and strategic,” he noted.

Now many pilots are flying with synthetic vision systems (SVS), which present an animated 3-D view of the outside world. “I would offer that we’ve made it much more natural to fly the airplane,” he said. “We migrated from mechanical instruments to a similar presentation that happened to be electronic. Now we allow the pilot to think mission-wise. That’s the biggest advantage of the SVS view; it’s more like what the pilot would want to think about to manage his mission. Mission-wise, there is no hard line between right now and five to 10 minutes from now.”

This fits in with what Witwer and his team focus on when designing complex systems. “Always give the pilot what he needs, only what he needs [if it is superfluous it can be confusing and misleading]; only when he needs it [understand what the point of the mission is, and if it’s not germane, don’t give it]; give the pilot this information in a way that’s intuitive, unambiguous and easy to understand [there are times when touch can be a helpful modality, and times when voice can be helpful].

“I’m going to keep my [team] totally fixated on continuing to advance this whole notion of machine-human collaboration and [on] pilots understanding what the machine is doing. Where the pilot will sit is a decision that will [come] down to who cares.”

Universal Avionics Cites Cost, Safety

Universal Avionics CEO Paul DeHerrera sees two key drivers leading to development of technologies for single-pilot and autonomous (no-pilot on board) aircraft: cost of operation and safety concerns. “Before a complete changeover to autonomous operations, an increase in oversight will begin to gain traction in future cockpits,” he explained. “This will include video recording [and] pilot, flight path and flight condition monitoring for the various phases of flight. For instance, deviations exceeding some predetermined distance from the scheduled flight path could trigger an onboard system to take action, including ground-based alerts and in extreme cases the complete override of control.”

There are some technologies deployed that help facilitate single-pilot operation, he pointed out, such as autofeathering propellers and autopilot emergency descent and unusual attitude recovery modes. Further development is needed for avionics to make a decision, although some of these systems already do so.

“In addition,” he added, “this type of operation will require extremely reliable datalink at sufficient bandwidth to enable a reliable link to the ground for the transfer of instructions or emergency operation. Depending on the specific situation, the onboard computer might provide a warning before executing a specific task, but it will act more like a co-captain [taking action] instead of just providing awareness and waiting for pilot action in the case of single-pilot operations, or in autonomous flight will execute automatically or as directed by ground control.”

While cost might dictate a move to single-pilot or autonomous flight in cargo aircraft first, a track record of safe operations there “would prove to the public that aircraft can be flown safely and, in many cases, just as safely as with two pilots or in autonomous flight without pilots.”

Before this can happen, however, some infrastructure would have to be deployed, including “strategically placed ground stations that could ‘accept’ an aircraft for autonomous control,” according to DeHerrera.

“The limits of line-of-sight for autonomous control of aircraft mean that the onboard FMS would need to be able to look at a database of autonomous ground stations. It would also need to evaluate the fuel on board [and] distance to station and fly the aircraft autonomously to a safe altitude, placing the aircraft in line of sight above the closest ground-based control station. This would enable the aircraft to be flown from a ground-based operation and land safely at a nearby airport,” he said.

Thales Taps Technology

The Thales design philosophy isn’t intended to eliminate pilots from cockpits. Of more importance is using technology to help pilots fly more efficiently and safely.

No matter how many pilots are on board, said Richard Perrot, avionics vice president of marketing, “[The pilot] remains at the heart of the decision, and at the same time he is getting better information. We really want the pilot to be able to manage the flight. As we’re providing more accurate information in the cockpit, the work is much easier because the decisions will be much easier.”

There is ample evidence that sole pilots can handle complex aircraft, he added, mainly in the military. “We’re doing it in general aviation as well. But airlines and larger business jets
continue to require two pilots and even three for long-range trips.

“We’ve reached a level of complexity that is almost a maximum for the pilot,” he said. To fix this problem, Thales continues to refine its Avionics 2020 design philosophy. “Our philosophy is to simplify the man-machine interface and present information in the most clever way we can: the right information at the right time.”

The primary Avionics 2020 interface is a large touchscreen that covers the entire instrument panel. “Instead of asking the pilot to go to the system to search for information, we bring the information to the pilot. The pilot remains in the center of the loop, but all systems are reworked to bring him more value.”

This might lead to the need for fewer pilots, he said, “because the way to operate the avionics might be easier, with less workload.” This could make operations such as ferry flights safe when flown by one pilot. Or a long-range business jet trip could achieve an equivalent level of safety with two pilots instead of three.

The Avionics 2020 design is aided also by advances in airborne connectivity. “We’re able today to bring information on board for the pilot to manage his mission,” he said. “This was not possible in the past. Connectivity is really an enabler for this new era.”

Another area that is already showing connectivity benefits is the sharing of weather and sensor data from aircraft to aircraft. Large fleets of airliners are being equipped with systems that can send data to weather providers, which disseminate information based on that data to other customers and fellow fleet members. Aircraft today typically maintain trajectory information in the FMS, Perrot explained, while the best weather information is disseminated to dispatchers on the ground. By mixing on board the most current weather information with the trajectory, he said, “This gives us the most accurate prediction for the pilot, so it’s a real help. And if three hours ahead the pilot decides to modify his flight plan, he will be able to avoid weather or turbulence.”

Pilots have been testing Avionics 2020 concepts in simulators for a few years and so far, he said, “Surprisingly they have had good reactions. We thought they would be conservative, but it has been completely the opposite. They immediately thought that the organization of information is putting them at the heart of the cockpit. They were pleased to see that it reduced their workload without reducing important information.”

Thales has also been testing head-mounted displays with Avionics 2020. “This opens a huge landscape of applications for the pilot,” Perrot added. “We are sure it brings added value in the cockpit in some aircraft where you cannot install a head-up display. We’re pretty sure this kind of technology will be implemented in the commercial world before 2020.”

Whether all of the Thales Avionics 2020 research translates into widespread changes depends on the regulatory climate. “I don’t think regulations will be removed too fast,” he said, “and regulations can change only if we provide the same level of safety as we have today.

“The only thing we can do is provide the most appropriate technology to support manufacturers with a new cockpit philosophy. Today we have made tremendous progress in terms of the man-machine interface and the information presented to pilots, and thanks to connectivity we can bring much more value in terms of mission management. It depends on the willingness of manufacturers to implement this technology.”