

COCKPIT AVIONICS

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by Matt Thurber

SPECIAL REPORT

Benefits offered by modern avionics outweigh automation anxiety among industry experts

Despite some distressing recent accidents, the level of safety in the ranks of professionally flown aircraft has never been better, and it is likely that modern avionics have a lot to do with that. Although discussions about too much cockpit automation inevitably crop up in relation to these accidents, the pace of technological change in cockpit avionics has accelerated, and avionics manufacturers continue to focus their engineers toward new designs and ways for pilots to interact with the increasingly complex aircraft that they fly.

The results of this effort will be incredible new capabilities, increased safety and efficiency improvements. And although many of these changes will occur behind the instrument panel and inside the boxes that run the software, the displays that present information to pilots and the way pilots access and manipulate that information are all undergoing profound change. Three key trends already in play will see further development. These are touchscreen controls, portable device integration with cockpit avionics and new ways of presenting information to pilots.

Touchscreens

When a young person who has grown up manipulating a tablet computer with multi-touch gestures is confronted with an "old-style" dumb monitor and tries to interact with the display by touching the screen, it's obvious where display technology is headed. For aviation applications, however, some constraints are forcing the development of touchscreen technology in certain directions.

Garmin was early out of the gate with touchscreen displays for certified avionics, with its touchscreen-controlled GTN series radios/navigators. These panel-mounted units are designed

for touch directly on the display. Although touchscreens can be challenging in turbulence, bezels on the sides of the displays allow anchoring of the hand to keep fingers steady. Avidyne's touchscreen-controlled IFD series of radios/navigators is due for certification shortly.

An obvious philosophy behind the design of these systems is that they are far more intuitive to use than their button-pushing and -turning predecessors, although buttons and knobs remain for those pilots who prefer that interface. The easier interaction offered by touchscreens mirrors the development of touchscreen-controlled consumer

electronics such as tablets and smartphones, hence the drive to simplify operation of modern avionics. Garmin took advantage of the iPad environment to create a training app for its GTN systems, and this is an excellent example of how consumer electronics supports modern avionics. Universal Avionics recently announced a new addition to the training choices with an iPad app that can be used as a control display unit with its flight management system (FMS) trainer.

So far, the use of touchscreen displays (as opposed to controllers) is finding application in larger airplanes with the Rockwell Collins Pro Line Fusion touch system for Beechcraft King Airs and similar-sized airplanes. Pilots are close enough to the instrument panel to make reaching a touchscreen display a reasonable expectation. Touchscreens for business jets are now available, in the form of Garmin's G5000 and G3000 systems, but these use touchscreen controllers as the primary interface, and the controllers are small enough to be installed within convenient reach of pilots. In some applications, Cessna's new Sovereign, for example, each pilot has two GTC 570 controllers within handy reach. Smaller airplanes such as the HondaJet with its G3000 system use two controllers. The first business jet certified with Garmin's G5000 system (also the company's first Part 25 certification) is Bombardier's Learjet 70/75. Cessna's new Citation Sovereign and X should follow shortly.

Honeywell is also well aware of the allure and benefits of touchscreen controls for not only the business jet market but also air transport and is developing controllers for Embraer's E-Jets (the Lineage 1000 in bizjet form).

It's still early days for these touchscreen systems, and they don't all use the same conventions. Multi-touch hasn't found its way onto most of these systems yet, probably because it might be hard to pinch-zoom a map on a display that won't hold still in turbulence. But these systems do, in most cases, eliminate the awkward and space-hogging cursor-control devices that occupy valuable console real estate, and that is a step in the right



Rockwell Collins is pioneering development of panel-mounted touchscreen displays with its Pro Line Fusion flight deck for King Airs and similar-size aircraft.

direction. Of course, even with the G5000, some cursor movement around the screen is still possible, using a small knob.

Portable Devices

Until recently, anyone talking about tablet computers in the cockpit usually meant an iPad, but Android devices have some aviation apps available, too, and now Microsoft is getting into the aviation hardware business with its Surface 2 tablet.

Microsoft is entering the aviation app game about three years late but received a significant order for Surface tablets from Delta Air Lines. Jeppesen is developing a version of its Mobile Flite Deck Pro for the Surface tablet for Delta, but this will also be available to other Surface users. The entry of Microsoft into the aviation app market may finally give the iPad some competition, which has been lacking in the Android environment. Garmin is the only iPad app developer that has seriously tackled the Android market, offering versions of the Garmin Pilot flight-planning and moving-map app for both platforms.

The problem with developing software for the Android is that there is less consistency in display size and operating system levels among the various devices that run the Android operating system, and thus writing apps is more complicated and costly. Nevertheless, Android devices are powerful and capable, and it won't be surprising to see more apps developed. If the Surface tablet becomes more popular—thanks to Delta—then this may end up a viable platform for aviation apps.

Another factor that makes tablet computers even more useful in cockpits is the proliferation of ADS-B receivers that bring free weather and traffic information onto tablets. Some receivers incorporate sophisticated sensors such as gyros and accelerometers that provide attitude information to drive instrument displays on the iPad, which could be used as an emergency backup if all the panel-mounted systems failed.

In the case of the iPad, external sensors may become moot, because the latest iPad Air and iPad mini are powered by Apple's new A7 processor and M7 motion coprocessor. The M7 manages the function of the sensors, taking the load away from the A7 and potentially allowing for app developers to incorporate some interesting new capabilities.

Pilot Presentations and Interfaces

Every time an airliner or, to some extent, business jet accident happens, questions are raised about what the pilots did or didn't do with the information that was available to them. For example, when the Air France Airbus A330 was held in a stall for nearly the entire last four minutes of its fatal plunge into the Atlantic Ocean in June 2009, many wondered why the pilots couldn't know that the Airbus was stalling. Is there a way of presenting information about the airplane's attitude that might have helped prevent this accident? How about, in such a dire circumstance, a simple pictogram showing a side view of the airplane and its unforgiving nose-high attitude? And at the same time, a silencing of the audio alerts that may have added to the pilots' confusion? This is not meant to criticize the Airbus design or the pilots who

were faced with circumstances that no one had ever envisioned, but merely to illustrate some of the post-accident explorations of the way information is presented to pilots.

Another example might be the Colgan Air Bombardier Dash 8, which crashed near Buffalo, N.Y. in February 2009. The flight crew failed to add power after leveling off during an instrument approach. Because the autopilot was on, the trim was rolled back in an effort to maintain the target altitude, which is exactly what the autopilot is programmed to do. When the pitch attitude reached a preset limit, the autopilot shut off, and one of the pilots pulled the control wheel aft instead of pushing forward and adding power. The result was an unrecoverable stall. What could avionics designers do differently to help a pilot deal correctly with this situation? What about a simple audio alert, such as "add power"? Or a simple autopilot modification that would automatically not allow the pitch to be raised to the point of stalling?

In fact, that latter feature is already available from some avionics manufacturers. Modern fly-by-wire flight control systems often incorporate envelope protection features that help keep pilots out of trouble. Aircraft manufacturers likely will incorporate more of these features on future airplanes; Embraer's new fly-by-wire Legacy 450/500 series is one good example.

The idea of protections to keep pilots out of trouble could, of course, be extended further into a pilotless airplane flown entirely by a computer. Surely, for example, a properly designed pilotless airplane computer would not forget to add power after leveling off? Indeed, it may be that avionics technology is converging, bringing together the best of the manned and unmanned aircraft environments, although there likely always will be a market for both types of aircraft. In any case, that is an entirely different subject that will be addressed in future articles.

AIN interviewed avionics manufacturers to learn what new products and research they are working on, especially to make flying safer and more efficient for pilots.

Universal Avionics

"Everybody loves to talk about new products," said Paul DeHerrera, who was promoted to the position of CEO at Universal Avionics Systems on Nov. 1, 2013. "That's first and foremost with us. Innovation has been in our DNA since day one, and that's not going to change. We're constantly introducing new things into the marketplace."

That said, Universal Avionics is not a company that chases after the latest fads. According to DeHerrera, "We did some internal work in



This Honeywell rendering illustrates the possibilities of future avionics. In addition to large displays that fill the panel, Honeywell foresees enhanced vision and sensing, improved pilot interface and modality options and an automated cockpit assistant contributing overall to an enhanced and more intuitive cockpit.

looking at strategy.” The goal was to find out what makes Universal Avionics special to its customers and what sets the company apart. While customers “love the buttons and touchscreens,” he said, the clear response was that the customer experience is most important. For Universal Avionics, that means not only designing innovative products (the company pioneered the FMS and also synthetic vision), but making them available for an array of aircraft, not just new ones but also the many older aircraft that can benefit from upgrading with modern avionics. “That’s a huge thing that has made us so different,” he said. “It frustrates customers, when they see it in magazines but they can’t have it unless they buy a brand-new aircraft. We love working with those guys; we can provide solutions and get them updated to the latest technology. That’s always been a great niche for us.”

A recent example of this philosophy is the Iridium satcom-based Dassault Falcon 50 Future Air Navigation System (Fans-1/A+)/controller pilot datalink communications (CPDLC) upgrade that Universal Avionics helped develop with Chicago Jet.

The supplemental type certificate (STC) program, the first Fans STC using Iridium satcom, was led by Chicago Jet. Universal Avionics provided its UL-801 communications management unit (CMU) and CVR-120A cockpit voice recorder, which integrate with the STC’s Iridium satcom (an International Communications Group NxtLink ICS-220A). Universal is working with Chicago Jet on its next Fans/CPDLC STCs, for the Falcon 900 and Gulfstream IV. Universal is also working with Clay Lacy Aviation on a Fans-1/A+ STC for the Gulfstream IV/IV-SP.

DeHerrera is proud of Universal Avionics’

accomplishments on complex programs such as the Fans STC. “That’s being adapted to a number of different platforms,” he said. “We’ve been working hard in all those areas and trying to give the customer a great experience. One of the things we don’t like is IOUs. We want to make sure it’s working right the first time.”

This year, Universal Avionics expects to receive certification for another key project, a new attitude heading reference system (AHRS) that incorporates analog outputs so that it is adaptable to older aircraft. “Most AHRS are digital,” DeHerrera explained. “We provide all those outputs so you can remove a spinning iron gyro and replace it with digital [sensors].” This will make removal of heavy old iron gyros much easier, allowing replacement with much lighter and more capable AHRS that can still communicate with older autopilots and attitude indicators.

Another area where pilots give engineers critical input is the subject of situational awareness as the flood of data captured by avionics grows exponentially. “There is so much information coming to the pilot,” DeHerrera said. “More is better, but sometimes more [information] can overwhelm a pilot. As we grow as a company and innovate, we have to be smarter; we can’t just dump it on the pilot. We have to get smarter about the phase of flight, what is important to the pilot or the situation.”

While Universal Avionics makes most of the components that can fill a flight deck, it doesn’t make an autopilot. Customers tell the company that if it does make an autopilot and thus can deliver a fully integrated avionics suite for new aircraft, they want that suite to have the same ease-of-use flavor as Universal’s FMSs, according to DeHerrera.

Universal is in the midst of developing a full flight deck (sans autopilot) for the MD Helicopters

Explorer, which it previewed at last year’s Heli-Expo show. A suite like this could be available for other aircraft manufacturers, too. “As far as the future and direction of the company, we feel there’s room for another player,” he said.

DeHerrera shares the pilot’s perspective, gained from flying in the right seat of the Universal King Air and Citation VII and also in his own Cessna 172. Touchscreens are getting a lot of attention, but his experience with a touchscreen portable GPS and the iPad on a trip last year in Texas highlighted the challenges of using touch during turbulence. “It helped me give feedback on what is good and bad,” he said.

Honeywell

Every avionics manufacturer employs experts who look into the future to try and divine the direction that new products eventually will take, and at Honeywell that role is filled by Bob Witwer, vice president of advanced technology. “There’s going to be so much change in the next 10 to 20 years, it’s going to be mind-boggling,” he predicts.

For prognosticators such as Witwer, an important tool is the whiteboard on which ideas are born and sometimes even take flight. Three thought bubbles held prominent spots recently on Witwer’s whiteboard, reflecting possible evolutions in cockpit avionics. The first bubble covered something that is familiar now to most pilots: forward-looking panel displays. In Honeywell’s view, these displays will increasingly deliver more information in the form of synthetic vision combined with enhanced vision systems (EVS) and other types of imagery. Witwer expects that the FAA will soon grant credit for lower landing minimums using synthetic vision, and this has been a key goal for Honeywell, which doesn’t manufacture a head-up display (HUD). HUDs already enable lower landing credit. Witwer also expects by 2020 that combined vision, which marries synthetic vision and EVS imagery, will be available.

Two other bubbles on the whiteboard represent developments in technology that pilots might carry on the aircraft, such as tablet computers and wearable devices. One area that Witwer is contemplating but that hasn’t made it to the whiteboard yet is a projection display. This would take information similar to that projected by a HUD onto the combiner glass in front of the pilot but project it onto existing parts of the airplane such as, for example, the windshield. This not only removes the combiner glass from the pilot’s field of view but also could eliminate the need for the pilot to position his head to view a specific area on the HUD combiner. “There is a lot of potential there,” he said, “and we have had some customers express interest.”



Universal Avionics is developing a fully integrated flight deck for the MD Helicopters Explorer. This mockup of the twin-engine helicopter's cockpit highlights some of Universal's unique design elements.

With regards to carry-on devices, Witwer sees additional utility through resolution of a controversial issue: the regulators' insistence that pilots not use these devices to depict the position of the aircraft (geo-referencing or own-ship position display). The own-ship feature is not likely one that pilots would want to switch off, but because these devices and their GPS receivers (internal or external) are not certified, the regulators feel that the depicted position might not be reliable. But what if that own-ship position could be validated somehow, Witwer asked. "That's a challenge we should [face], to get functionality on these portable devices."

Taking this a step further, Witwer suggested creating a device that could be certified, in a way that makes the device just a portable piece of avionics. "I could see where once we have the capability of putting avionics functionality on this device, the only difference between this and installed avionics is the fact that it isn't installed. It could be an integrated modular avionics device, able to host functions of different design assurance level criticalities."

Of course, there are already ways that pilots can use their iPads to interact with onboard avionics. Aspen Avionics' Connected Panel system allows pilots to send flight plans from the iPad to avionics and also to change frequencies, among other capabilities. Other companies make devices that deliver systems information from the aircraft to portable devices, including GPS data from certified receivers, so Witwer's ideas might just be a logical extension of current technology. In whatever form this takes, wireless communication between the portable device and cockpit avionics is a given, according to Witwer. Security will be an issue that needs to be addressed, he said, "or how to provide for a wireless connection in an aircraft and ensure it's high-integrity. I think that's a solvable problem."

The wearable displays idea stems from the growth of Google Glasses, which poses, he said, "the idea of being able to have information that's within your field of view or field of regard." Witwer anticipates a "near-to-eye" display allowing pilots to see a conformal image of the outside world, which follows the pilot's eyes via a head-tracking capability. This could show, for example, a combined-vision view with synthetic and enhanced vision imagery, supplemented by real-time airborne and ground traffic provided via ADS-B, no matter which way the pilot looks. "It's just as if you're carrying the HUD with you," he said. This "portable HUD near-to-eye" display could be used for more than just providing lower landing minimums.

In the FMS arena, Honeywell's latest FMS in

the Boeing 747-8, Gulfstream G650 and Falcon 7X represents a new way of fitting FMS functionality into various airplane types. The core navigation sensor and guidance functions are the same, no matter which airplane the FMS is installed in, but the manufacturer gets to tailor some elements of FMS presentation to its liking. "This doesn't impact the core functionality," Witwer explained. This design allows Honeywell to deliver upgrades and fixes across the fleet that uses this FMS without affecting the interface chosen by the manufacturer.

Honeywell also sees a future opportunity with the 3-D taxi view. "We've changed how pilots fly aircraft a lot," Witwer said, "but we've done little on how they taxi." The only improvements for taxiing have been 2-D maps and own-ship displays on electronic flight bags and tablet computers. But Witwer would like to move that model further into a 3-D view, to give pilots similar situational awareness on the ground. With a 3-D taxi system, for example, a pilot could upload a "taxi plan" and follow a magenta line on the display. The taxi would begin by showing the pilot an exocentric view from "outside" the aircraft, he said, "almost as if you're parasailing behind the aircraft. When the pilot gets to the threshold, it's almost as if he gets reeled back into his seat looking out the window. The opposite happens when he lands and slows to a certain speed; then it's back to the exocentric view."

Other Honeywell avionics developments include more work on touchscreens, to include using touchscreen controls as opposed to adding touch to panel-mounted displays. Voice control of avionics may be coming for business aviation, but Witwer doesn't expect to see this in the air transport industry. The NextGen concept of 4-D

trajectories is coming relatively quickly, to add room for squeezing more aircraft into the limited amount of available airspace, otherwise known as performance-based navigation (PBN). The PBN concept adds precise timing to a flight plan, so reservations will be timed down to the second. "You'll only have push back when you're going to have a clear nonstop path," Witwer said. "That is going to be a big deal."

Honeywell's latest FMS is capable of handling 4-D trajectories and can already handle curved PBN approaches. "These are new technologies we're bringing to the market," said Ken Snodgrass, Honeywell v-p of marketing and product management, platform systems.

As part of making the avionics interface simpler for pilots, Honeywell is investing in display of data-driven chart information. Instead of plopping an electronic version of an existing chart, say an approach plate, onto the multifunction display (MFD), the chart information can be drawn on a moving map, just showing the information that the pilot needs at a particular time. While the data might come from many different sources, this will be transparent to the pilot. "You don't need a map and a chart," he said, "now it's all together."

With all that data needed to provide information to pilots, keeping it updated could become complicated. But new faster satcom systems are coming, and Snodgrass sees these leading to aircraft flying around with an always-on link to the ground. Honeywell is the exclusive reseller of airtime and hardware for business jet users of the upcoming Inmarsat GX Aviation ka-band satcom. "GX will lead to always-on communications," he said. "There is so much you can do once you have that." This includes constant database



Gulfstream's PlaneView II flight deck in the G650 is the most current technology cockpit offered in a new business jet. Based on Honeywell's Primus Epic avionics, PlaneView features include EVS II infrared enhanced vision system, HUD II head-up display, synthetic vision on the primary flight displays, triplex FMS, automatic emergency descent mode and Honeywell IntuVue 3-D weather radar.

updates instead of waiting for a 14- or 28-day cycle. Such a link could also enable handing control of the aircraft over to a pilot on the ground if, say, the airborne pilots became incapacitated. Of course, this concept requires a secure connection, and Honeywell has taken that into account.

Rockwell Collins

Cockpits of the near future likely won't look much different from the latest flight decks now flying, according to Matt Carrico, senior engineering manager of advanced concepts at Rockwell Collins. However, he added, "The latest ones are going to be setting the trend for 2020. Those are characterized by a large amount of display surface that give a lot of information, and increasingly by head-up displays [HUDs] being adopted by the business aviation market for their value in approach and landing. Those types of cockpit offer great situational awareness and improving capability to fly in NextGen airspace and operate in a degraded visual environment on the surface."

HUD is a big part of Rockwell Collins flight decks, and the company's Head-up Guidance Systems division is busy developing the new HGS-3500 compact HUD for turboprops through midsize jets. The HGS-3500 eliminates the bulky projector mounted on the cockpit ceiling, thus enabling installation in a wider variety of aircraft, and it costs much less than larger HUDs, too.

"We like to think the best way to fly an airplane is heads-up and eyes forward, and that's part of the reason we have the focus on HUD and on vision systems," Carrico said. "With the new HVS [Head-up Vision System] the pilot can see through those obscurations and perform what looks like a visual maneuver in non-visual conditions. Airplanes are getting provisioned at the factory with wiring for dual HUDs and we're seeing more operators elect to install dual HUDs. If that trend continues, in 2020 we'll see more cockpits with HUDs and more with HUDs on both sides and way more with large displays."

Rockwell Collins HUDs in Pro Line Fusion-equipped jets can display synthetic vision system (SVS) imagery. The company's latest development is HVS, which displays both SVS and EVS images on the HUD combiner. The EVS is multispectral, which means the EVS's uncooled infrared camera can detect not only normal infrared emitters, such as incandescent lights and other heat-generating features, but also LED lights that are growing in use for runway lighting systems.

Now Rockwell Collins engineers are working on how to combine the SVS and EVS imagery into



Big displays are proliferating in modern cockpits, shown here in this Rockwell Collins Pro Line Fusion flight deck. A unique feature in the Fusion synthetic vision display (which is also visible in the synthetic vision image on the associated head-up display) is the destination airport dome blooming above the compass rose.

a single image "that gives the best possible view of the outside world to the flight crew," according to Carrico. With SVS imagery displayed on the larger HUDs in Pro Line Fusion cockpits, the next step is bringing that capability to the compact HGS-3500 then combining it with EVS. "With that EVS sensor," he said, "how can we combine EVS and SVS to get the best possible view to the pilot, especially on landing? We're also looking at how we can use vision systems for takeoff and operating on the ground for the taxi phase."

Rockwell Collins has been flight-testing its new Pro Line Fusion touchscreen displays in a King Air since October 2012 and expects to receive certification by the end of this year for the King Air upgrade. "They're self-discovery interfaces, you just do what feels natural," Carrico explained. "If it's designed right, it behaves the way you expect. We've done some things with radio tuning using touch displays that really reduce workload. It's so much more intuitive than having to dial every number. This is another case of automation done right, where you do something that doesn't degrade skills and helps the pilot become a better pilot. That's the type of automation we're focusing on with the next generation of human-machine interface."

While these displays don't work with the multi-touch gestures that are familiar to users of smartphones and tablet computers, that may change in the future. "We are looking seriously at the multi-touch human-machine interfaces that will enable people to interact more intuitively, like with consumer devices," Carrico said. The Pro Line Fusion displays in larger jets are just too far away for pilots to reach, and for these applications Rockwell Collins is exploring touchscreen controllers.

For Pro Line Fusion cockpits already in

service, Rockwell Collins recently released enhancements to help meet upcoming NextGen and Single European Sky ATM Research (Sesar) program requirements. These new features include RNP AR 0.3, vertical situation display, automated speed selection and takeoff and landing calculations using the FMS, and interactive electronic checklists, which include user-defined checklists.

More cockpits will feature these NextGen capabilities as the mandates in various countries kick in (some ADS-B mandates are already in place for altitudes above FL290 in the Asia-Pacific region, and Fans/CPDLC will be required on two center North Atlantic tracks from FL360 to FL390 in February).

It remains a question whether operators will want to install upgrades beyond those that are mandated, he added. Capabilities such as ADS-B IN and the ability to fly RNP approaches aren't required, but they do offer benefits. "I think we'll see that if airspace enables the expected benefits from these new capabilities, then we will see a demand for some of these optional features. It's kind of a big if. It does depend more on the operational side of the FAA and Eurocontrol enabling benefits for airplanes that are equipped. If operators find that they do get a benefit, we'll see demand for some of these features, which might in turn drive additional upgrades. Pro Line Fusion—in terms of incorporating new features with added software—if there is demand, we'll be able to respond to that."

Rockwell Collins has long been dealing with security issues related to the flow of data between aircraft and information delivery systems. This became of even more import after the company's

Ascend Flight Information Solutions division developed a system to deliver database updates directly to aircraft over the Internet, eliminating the need for pilots or mechanics to install updates manually.

A key lesson that Rockwell Collins has learned in dealing with data security issues, he said, "is that you're never done; the threat is always evolving. As we implement these new features, how do we keep them robust throughout their lifecycle? This is forcing us and our operators to understand this new world of evolving threats and to make sure the equipment stays up to date. The idea from that point is not to change [the data] so it remains in the certified and configured state," Carrico said.

Rockwell Collins participated in the recent aviation rulemaking committee that made recommendations to simplify and streamline the certification process for small aircraft certified under Part 23 of the FAA regulations. While this doesn't apply to many of the products that Rockwell Collins makes, the company is moving into the Part 23 market with the touchscreen Pro Line Fusion displays. "We support that effort to help revitalize the lighter end of the industry," said Roger Southgate, director of the avionics certification office for Rockwell Collins. "The transition to a simplified regulatory basis supported by industry consensus standards is a good thing for the Part 23 community. Following some experience of that, I can see the extension into perhaps Part 27 [light helicopters] and ultimately Part 25 [large airplanes] and Part 29 [large helicopters]. It'll be a gradual process. There needs to be an acceptance of the transition away from prescriptive to performance-based [certification], supported by those kinds of standards."

Although there is pressure on the FAA to accelerate the process of adopting the Part 23

committee's recommendations, Southgate sees a solution that could work in the short and even medium term. "We have a solution available to us with the FAA designee system. They can delegate compliance findings, through the ODA [organization designation authorization system]. The fact is the FAA is not taking full advantage of that ability. If I were to pick the quickest and easiest way to provide relief to the certification bottleneck, it would be to make full use of the existing delegation.

"We have an ODA for STC functions, at the installation level, as well as for TSO and PMA and the production function. That is the issue for companies that are qualified and have become ODAs—the FAA has struggled with fully using the capability that is available to them."

That said, the FAA has been most helpful in the certification program for the Pro Line Fusion touchscreen displays, according to Southgate. "We were fortunate in the last round [of government furloughs]; they occurred at a time when we were fairly well caught up. Our [aircraft certification office] in Wichita was cooperative and worked with us just ahead [of the furlough] to clear several of the more pressing approvals we had in the pipeline."

These problems aren't confined to the U.S., and some of the same resource constraints are evident to companies seeking EASA certification for their products. "They have some of the same problems, despite the fact that we're paying for the service," Southgate said. "In one respect it should be easier, because the initial certification is always with the FAA. When we go to a foreign [regulator], their function is to validate the FAA certification. It should be much simpler and a much lower level of effort. To a degree it is, but sometimes the EASA re-reviews to a greater extent than it ought to. They're suffering the same kind of resource constraints as the FAA, but for different reasons. The European Commission is

working through its own austerity measures and requiring government agencies to achieve budget levels, and this will result in staffing reductions or less cover for roles and responsibilities."

The bottom line for a major avionics manufacturer isn't necessarily the effect on how much time it takes to bring a product to market, but the unpredictability of the certification process. For example, one project might take 15 days for FAA approval, then a similar product might take 45 days. "It depends on how it falls, what their workload is when it gets there and the perceived complexity compared to the previous [product]," Southgate said. "That's what makes it hard to plan. Whether the cycle time is 30 days, 10 days or five days, we don't care as long as it's predictable. Under a fully delegated system where we're providing the resources, since it's our resources, it becomes predictable. Now we can plan our business. If we did it right, a furlough should have zero effect."

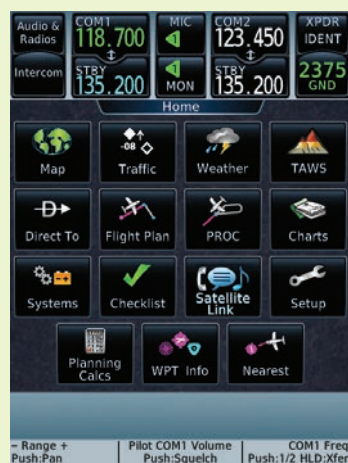
Garmin

Garmin scored a significant achievement in early November when the FAA awarded certification to Bombardier for the Learjet 75, the first Part 25 certification of a Garmin integrated flight deck, which includes a Garmin automatic flight control system. The Learjet 70/75 is equipped with Bombardier's Vision cockpit—based on Garmin's G5000 suite—and this is the first certification of a touchscreen-controlled integrated avionics system in a business jet. More G5000 business jet applications will follow this year, with Cessna's new Sovereign and X (also including Garmin-designed autothrottles), then later the Latitude and Longitude. Garmin's G3000 Part 23 touchscreen system is featured in Cessna's upcoming M2 and Honda's HondaJet.

With these programs certified or well on their way to approval, between now and 2020 Garmin's flight decks aren't going to change much, at least the way they look and work, but they will feature more connectivity and convergence of data, according to avionics product manager Bill Stone.

The goal is to design the system so that the right information is presented to the pilot at the right time. "Much of what we do is context sensitive," he explained. "We present options and the like only for the task currently at hand. That leads to good human factors and makes the equipment discoverable; you're not relying on mental muscle."

With its first Part 25 certification done and many more under way, Garmin is looking to the future of avionics design. "There are always ways we can expand our portfolio, whether it's additional functionality or capability or to meet regulatory requirements," said Stone. "We're not done. There are



Garmin's G5000 system employs the far more intuitive icons shown above on the GTC 570 touchscreen controller. This vastly simplifies the avionics interface for pilots, who can quickly pull up information such as the synoptics chart below.

definitely opportunities and we're pursuing them."

To help pilots prepare to fly the G5000 system, Garmin has released an interactive online training system. "We're making a significant investment in that regard," said Stone, and Garmin plans to extend that training method to the G3000 and G1000 systems. The obvious benefits are that pilots can practice using the avionics before going for training. And in the case of G1000-equipped King Airs, for which there are no simulators, pilots will have a way to learn how to use the avionics. "We feel that off-aircraft training is pretty valuable," he said.

As for the G1000 system, Garmin was aiming for a late-December release of the 13.05 software upgrade, which will fix some deficiencies that users had identified. One of the major changes is that pilots will be able to set up user-defined holds anywhere, something that most other avionics systems have long offered. The new hold feature will allow setting up a hold both at any point in a flight plan or at a direct-to point anywhere else. "User-defined holds are a popular item that people have asked for," said Creighton Scarpone, Garmin's north central regional sales manager.

Other new capabilities include compatibility with the Garmin GRS 7800 AHRS, which will allow operators in northern Canada to remove a restriction and fly to 84 degrees north latitude. The new revision will also enable pilots to fly radius-to-fix curved approach legs during Rnav approaches, a technique that is still relatively rare in the U.S. but destined to become more widespread.

Innovative Solutions & Support (IS&S)

The most notable recent development for IS&S is its UMS-100 Utilities Management System (UMS), according to company president Shahram Askarpour. The first customer for the UMS is Pilatus, which selected the UMS-24 version for its under-development PC-24 utility twinjet.

What makes the UMS significant is that it puts IS&S in the position of integrating many aircraft functions in a small number of electronics boxes, just four in the PC-24. These boxes don't just manage avionics functions but also integrate the avionics with flight controls and landing-gear actuators, environmental control, electrical, oxygen, lighting systems and so on. What the UMS does is eliminate the need to have separate controllers for all these functions, saving weight and complexity, lowering power requirements and improving reliability.

Although Honeywell is providing the PC-24's

avionics suite, IS&S could do so and does on other platforms, such as the Lockheed C-130 panel upgrade for the UAE air force and the Eclipse 550 very light jet's integrated flight deck. "When you put together the UMS with our display system, essentially we provide a complete avionics solution to the aircraft," he said. The only products that IS&S doesn't make are radios, radar and the autopilot servos. But the UMS does allow it to house algorithms in the UMS to control autopilot servos, essentially the heart of an autopilot.

Since IS&S announced that it was selected to provide the UMS for the PC-24, Askarpour said, "we're seeing a lot of interest" from other aircraft manufacturers, both large and small. The UMS would be ideal, he added, for fly-by-wire flight controls. "We can do a high degree of integration with fly-by-wire," he said.

have minor impacts on the appearance of cockpits," Champagne explained. "Screen real estate dedicated to datalink communications and understanding of the air traffic management picture will become more prevalent. More cockpits will have variants of synthetic vision/EFVS/fused sensor and synthetic imagery supporting primary flight displays. The trend will be towards larger display surfaces that can provide better display of situational awareness features. Controls such as touchscreens, variations of cursor control devices and voice activation of features will increase."

The push for these improvements is not just natural technological progress but also a response to demographic changes in the pilot population. "With significantly increased demand projected for pilots in the period between now and 2020," he said, "and the pending retirements of an aging pilot population, there is a real probability that



The Eclipse 550 very light jet features a fully integrated flight deck by Innovative Solutions & Support. Instead of FMS control-display units, two retractable keyboards are available for alphanumeric input.

Esterline CMC Electronics

Esterline CMC continues to explore core technologies that can "enhance overall cockpit and crew effectiveness and capability," according to Patrick Champagne, v-p of cockpits and systems integration. "Our approach is to observe the aviation industry to identify the problems that are causing most difficulty to operators, and then to direct our engineers toward identifying improvements to our products, or identifying new products that can provide relief from these difficulties."

For circa-2020 cockpits, Champagne said that the technologies that pilots should expect to see are "already maturing or at least being investigated for feasibility." These include air traffic management capabilities to meet NextGen, Sesar and other countries' upcoming airspace mandates; visualization techniques to improve pilot situational awareness; large and flexible display surfaces; and control interfaces inspired by consumer electronics. "The manifestation of these changes will

training quality and the experience levels of pilots will suffer, which could affect overall safety. Avionics improvements will attempt to offset these potential demographic effects to enable a continuing trend of aviation safety improvement."

A trend that has been accelerated by younger pilots entering the industry is the increasing use of consumer-grade products such as tablet computers in cockpits, and Champagne sees this trend continuing. As a manufacturer of certified electronic flight bags, CMC recognizes the benefits of consumer devices but also the risks. "The threat to this trend will be if these inexpensive apps get on a collision course with aviation safety," he noted, "in which case regulatory reaction could start to slow the rate of proliferation."

Thales

Thales demonstrated its Avionics 2020 flight deck at the NBAA show last October. The system is a human-machine interface designed to preserve

COCKPIT AVIONICS

pilots' cognitive resources, thus enabling pilots to focus on making decisions. In other words, this is a cockpit designed for airmanship, according to its promoters. The development schedule of Avionics 2020 should suit a business jet program aiming at a 2020 entry into service.

"The idea of carrying out a mission is key to business aviation; therefore, business jet pilots often have to deal with changing requirements, sometimes in flight," said Denis Bonnet, head of cockpit innovation for Thales. Thanks to extensive use of touchscreens, Avionics 2020 makes planning a flight or changing a destination after departure more straightforward, he explained.

Sylvain Hourlier is Thales's human-factors senior expert and design authority. He and his team are endeavoring to give the pilot better situational awareness while reducing the cognitive workload. Hourlier sees four design drivers:

- "We help the pilot anticipate," he began. This can be done via the "timeline," a depiction of the flight's successive events. On the timeline, the pilot can zoom in and see any upcoming changes, such as waypoints, altitude, aircraft configuration and so on.

- "We help the pilot have a clear image of the actions he chooses to delegate." When assigning the autopilot to capture a heading, for example, the pursued heading will be shown in blue on the main display.

- The third design driver is schematics and systems depictions. "Let's first avoid views of the systems that are too complex," Hourlier said. When

a problem arises, the pilot will first be given a broad picture to show where the issue is on the aircraft. Then, if desired, the pilot can—by a single touch input—enter a more detailed level of representation.

- The fourth design driver has been to make learning as swift as possible. A new interaction must quickly become a routine, thus freeing the pilot's mind. Thales engineers have mimicked everyday-life protocols, such as the pinch-to-zoom gesture that is familiar for smartphone owners. An easy protocol is preferable in a stressful situation, Hourlier emphasized. This also translates into straightforward actions and views. When selecting an airport on the moving map, the pilot can drop the radio frequency into the list on the communications display. The pilot can see the radio frequency sliding through the displays, from the map to its position on the list. "This not only looks nice," he said, "Using cognitive continuity is also powerful in saving mental resources."

The Avionics 2020 flight deck is the outcome of extensive work by specialists; nevertheless, it is only a concept that airframers may feel free to customize. Some issues remain open. For instance, Thales engineers are still discussing whether it may be better to dramatically change the display's layout to specifically address degraded conditions. Ultimately, a business jet flight deck featuring Avionics 2020 may look relatively different from the demonstrator, while adhering to the philosophical human-factors underpinnings of the concept.

Aspen Avionics

Aspen Avionics sees opportunities for more innovation in avionics development in the way

aerospace companies work together to drive future developments. Aspen's signature product is its unique glass panel, which mounts in two standard round-dial instrument holes, making upgrades far easier than ripping up an instrument panel to install a larger rectangular display. The company also pioneered the Connected Panel system, which connects devices such as iPads to cockpit avionics, with a secure two-way flow of data between the aircraft and the device.

A further development of the Connected

Panel is the adoption by Pilatus of Aspen's Connected Gateway device as a means of updating onboard databases. While normally the Connected Panel system works with Aspen Evolution displays, the Pilatus application is the first where the Connected Gateway connects to a non-Aspen avionics system (Honeywell's Primus Apex in the PC-12). This represents, according to Brad Hayden, Aspen v-p of marketing, an excellent example of companies working

together. "That is where the innovation is going to come from," he said. "That is an indication of where Connected Panel is going and how people will use it. Connected Panel is a standalone offering. And there are other OEMs interested [in using it]."

However, there are obstacles to more widespread adoption of systems like Connected Panel, and this is because not all manufacturers are eager to play in that sandbox. Aircraft manufacturers, as Hayden pointed out, "control all the plumbing." In a retrofit, it's often challenging to be able to gain access to all the aircraft's systems to hook them into a system such as Connected Panel. Engine instrumentation, for one example, remains a major roadblock. "That's what people are up against," he said.

Aspen's roadmap for the future shares challenges similar to those that other avionics manufacturers are facing, specifically how to integrate the voluminous data flowing into cockpits and present it to pilots in a way they can safely put it to use.

Another factor that is helping is the anticipatory computing trend, where the system can help



Aspen Avionics has managed to stuff an enormous amount of information into its Evolution display, which conveniently fits into two



The Thales Avionics 2020 demonstrator is used to highlight capabilities that could come into play for a circa-2020 business jet flight deck. Controlled entirely by touchscreens, the Avionics 2020 design aims to preserve pilots' cognitive resources so they can focus on decision-making and not fiddling with avionics.

a pilot by offering the information needed in the context of the aircraft's location. Hayden sees that trend continuing "as the technology becomes more affordable," he said. "On the hardware side we'll see the cost of components come down, and that will enable anticipatory behavior. We also see algorithms developing that are more capable and robust and able to process the information so that the system can be more anticipatory."

FreeFlight Systems

Tim Taylor, president and CEO of ADS-B equipment manufacturer FreeFlight Systems, sees a transformation occurring in cockpit avionics, thanks to the rapid progress of aircraft systems, especially those based on modern microprocessors. Two key developments, he explained, are that aircraft are now equipped to gather much more information or state data and that the information that can be created by this data needs to be shared effectively. "We see a self-forming network of information flowing to and from the aircraft, aircraft-to-aircraft and to the ground."

Naturally, equipage for upcoming ADS-B mandates is all part of this environment because ADS-B involves precision position information via GPS and datalink the information to ground stations and sharing it with other aircraft in the vicinity. "It's about grabbing precise information, knowing how good it is and presenting it so the flight crew and [those on the] ground are managing the whole thing and operating smoothly in that environment," he said.

Trig Avionics

Transponder and VHF radio manufacturer Trig Avionics aims to develop other product lines, according to CEO Andy Davis. "Our ambition is to be a fairly broad general aviation avionics company," he said. "We have projects going on in a number of areas that will complement what we already have. Our goal is to provide an alternative to some better-known names, as a provider of avionics stacks." That said, he added, "We're not going to challenge Honeywell for business jet cockpits."

What has driven and is driving innovation in cockpit avionics, according to Davis, is the availability of relatively inexpensive displays, thanks to the explosion of LCD manufacturing for consumer electronics. This generally makes it easier for pilots to learn to fly because information that used to be scattered on a bunch of different instruments is consolidated on large

displays and, if designed correctly, makes the information easier to interpret. "I think there is an opportunity to replace a lot of that older technology with more intuitive displays, user interfaces, little captions, color codes, depending on what the instrument is," he said.

The next trend will be simplifying alerting systems to keep from throwing too much information at pilots, Davis explained. "We're going to start to move to a concept where an alerting system—if isn't going to tell you anything—will be made to go away." If the information isn't critical, then the annunciators on the display should remain dark so that pilots can concentrate on flying the airplane. "That is the change that I think is going to start to come," he said. "We may be at the peak of the bells and whistles and toys and starting to move to more muted displays."

Avidyne

Avidyne is nearing certification of its touchscreen FMS/GPS navcoms, the IFD540 and IFD440. Unlike other touchscreen panel-mounted avionics, the IFD540 and IFD440 are fully capable of manipulation using typical multi-touch gestures such as pinch-zoom and graphical flight-plan editing. Avidyne has also incorporated advanced features, including the capability for inserting a holding pattern at any point, automatic waypoint nomination (GeoFill) and automatic nav frequency tuning. The IFD540 and IFD440 are designed for plug-and-play replacement of Garmin GNS530 and GNS430 units, fitting into the Garmin racks in the panel with no wiring changes.

As ADS-B becomes more mainstream leading up the 2020 equipage mandate in the U.S., Avidyne has been working with the Massachusetts Institute of Technology and the FAA on industry standards for conflict detection and alerting. The Traffic Situational Awareness with Alerts (TSAA) program is a three-year \$4 million effort and includes prototyping and demonstrating functional hardware. The goal is development of new minimum operational performance standards (Mops) and a new technical standard order (TSO) so that other manufacturers can build equipment to meet the new standards.

Avidyne has already incorporated much of this research into its own traffic systems, under the brand name VeriTas. The VeriTas system consists of correlation of active targets (from Avidyne's traffic advisory system) and passive targets (from ADS-B receivers); predictive collision-avoidance logic; multiple alerts, including a second alert when necessary; and elimination of alerts while on the ground or from ground targets during approach to an airport.

SmartPlane

At the lighter end of the market is a company called Smartplane, which is developing an entirely new avionics system and interface for its Smartplane light sport aircraft (LSA). The Smartpilot avionics system, while targeting the LSA market, could find applications in larger aircraft, especially those flown by non-salaried pilots.

The Smartpilot user interface design is complete, according to company founder Stéphane Fymat, including application for and receipt of worldwide patents to protect the design. The next step is to embody the design in hardware and software that can be mounted in the Smartplane LSA (also a new design). Fymat expects to have a fully functioning prototype of the avionics operating by mid-year.

Smartpilot employs a highly visual interface that is easy for a pilot to interpret. The idea is to avoid having the pilot pull out charts when planning a flight or when revising a flight plan while in flight. Smartpilot doesn't just show the pilot how to get somewhere but its auto-routing algorithm optimizes the choice by evaluating a variety of factors.

A typical flight from point A to B is simple: just draw a line between the two. But what if there are constraints affecting that path, such as a TFR during a presidential visit or weather or changing winds? Smartpilot will evaluate the options and suggest a time that might fit the pilot's criteria—a departure time, for example, that allows arrival at the destination after the TFR expires or a departure after the weather improves to some specific level. And during the flight, Smartpilot will monitor all the factors and warn the pilot if the weather worsens or the TFR duration is extended and then help the pilot pick a suitable alternative.

"We can evaluate many options," Fymat said, "more than what you're able to do manually. We can look at an optimal time or path and might discover better options than you can on your own." Autorouting, he added, "is agnostic to the type of aircraft, but it will factor in aircraft performance. It will take into account what can this aircraft do? [For example], can it go through known-icing conditions or not? So that has immediate applicability to larger or different types of aircraft."

While the Smartpilot algorithm is focused on real-time tactical trajectory analysis, Fymat sees an opportunity to develop further capabilities that could help prevent a pilot from making a mistake, such as the Asiana Airlines accident in San Francisco where the speed dropped unrecoverably low. "Other [algorithms] we have on backlog would address that," Fymat said. "It's in our view to do something along those lines in the future." □