

# FIXING THE MAX

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**B**oeing is standing behind the baseline design of its 737 MAX as it seeks to restore industry confidence in the grounded twinjet and secure approval of a newly tested package of flight-control software and training upgrades meant to break links that helped form two 737-8 accident chains in five months.

The company, which continues to build the newest 737 version at full rate despite having to stop delivery of completed aircraft to operators, maintains that the MAX is fundamentally safe to fly and was developed in accordance with accepted industry hazard-classification practices and design procedures. But information shared in the just-released interim report on the second 737-8 accident, the March 10 crash of Ethiopian Airlines Flight 302 (ET302) suggests that failure modes envisioned for a key flight-control system were not well understood and emergency procedures relied too much on rapid analysis and prompt responses by pilots.

Boeing acknowledges there are key lessons to be learned from the two MAX accidents and that its updates are specifically designed to improve the "robustness" of the functionality of the flight-control law implicated in the Lion Air Flight

- > SOFTWARE UPGRADES TARGET RELIABILITY, SYSTEM AUTHORITY
- > DEBATE OVER ET302 PILOTS' RESPONSE
- > FLEET TO REMAIN GROUNDED FOR WEEKS

610 (JT610) crash in October 2018 and emerging as a factor in ET302. Boeing also is rolling out a package of crew-training updates that highlight the changes but do not require a complete syllabus rewrite.

The manufacturer's priority is to convince regulators and operators that the software and training updates will safeguard against further accidents and allow the grounded fleet to return to service and deliveries of new aircraft to resume. There is high confidence within the company that the update will receive regulatory approval.

On April 2, based on recommendations from a team of former Boeing engineers, the company extended the time line for presenting a finalized package to regulators. Brought in to review the software update, the team found "integration issues" between the software and the airplane that have to be addressed, a senior executive explains.

"It's not because the government is telling us [the package] needs more work," the executive says. "We're saying we have some more work to make sure everything is compliant, to make sure the software rolls out [correctly] the first time, and works the first time."

Boeing says the revised time line has the package being presented to regulators around May 1. From there, timing for implementing the changes and clearing the MAX to return to flight is in the hands of certification authorities. The FAA says it has assembled a group of representatives from

at least nine national regulators and NASA to "evaluate aspects of the 737 MAX automated flight-control system, including its design and pilots' interaction with it, to determine its compliance with all applicable regulations and to identify future enhancements that might be needed." Former NTSB Chairman Christopher Hart is chairing the team.

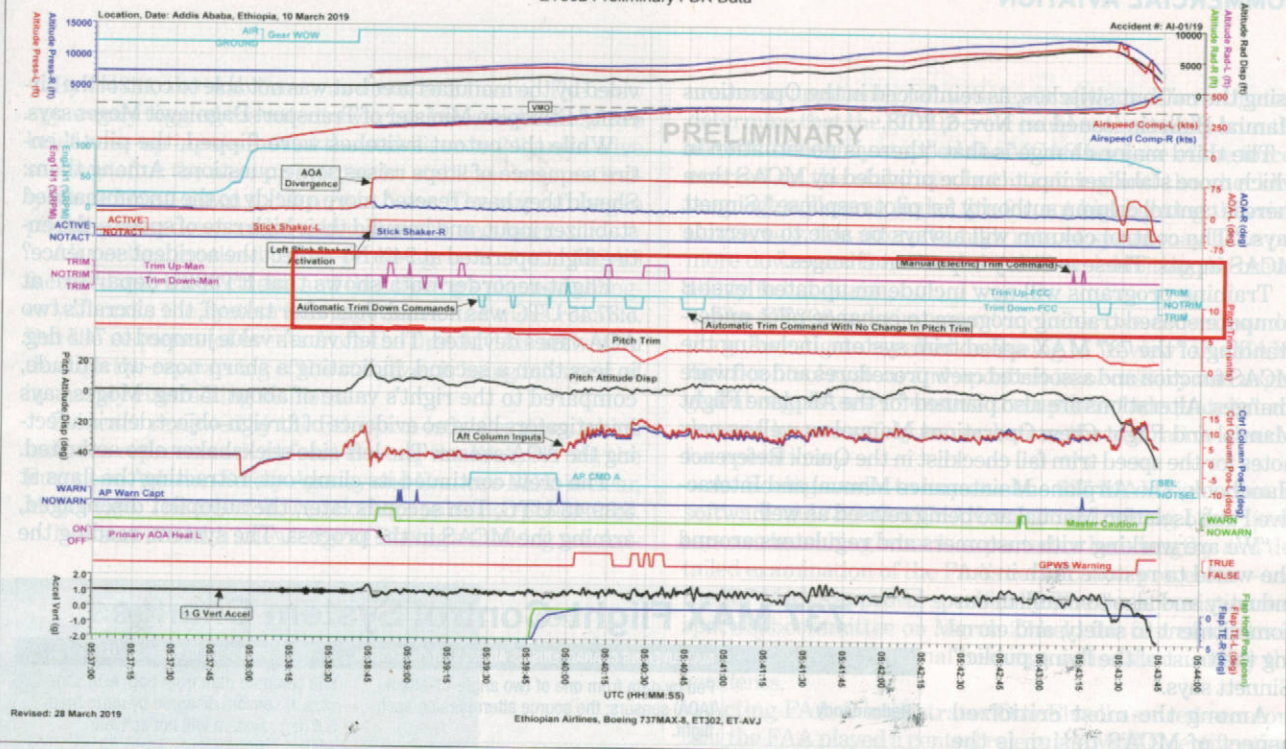
At the heart of the upgrade are three major changes to the MAX's Maneuvering Characteristics Augmentation System (MCAS) flight-control law, which was added to the twinjet's speed trim system to make the new aircraft handle in the same manner as the 737 Next-Generation family. The changes prevent the system from activating in case of erroneous data from angle-of-attack (AOA) sensors as

**Boeing's MAX fleet will be grounded well into May, and perhaps longer.**



MARIO TAMAYO/GETTY IMAGES





well as from activating multiple times for each elevated AOA input. Third, the revision now gives pilots ultimate elevator authority by limiting the degree of nose-down stabilizer commanded by the MCAS.

Outlining the changes, Mike Sinnett, Boeing Commercial Airplanes vice president of product development and future airplane development, reiterates the company's confidence in the overall safety of the MAX, the way it was designed and the ability of the upgrade package to enable flights to resume. "We have built our reputation on safety, and every one of us feels the weight of the burden of safety," he says. "The rigor and thoroughness of the design and testing that went into the MAX gives us complete confidence that the changes we are making will address all of these accidents. We look forward to working with all of our 737 MAX customers as we implement this, from the reentry into service to pilot training through the life cycle of the airplane."

The system's modifications, being developed as a software upgrade, were first demonstrated for the FAA on March 12, Aviation Week has reported (AW&ST March 25-April 7, p. 16). Boeing also will update training documentation as well as procedures. The proposed package of changes was demonstrated to 200 pilots and regulators gathered in Seattle on March 27.

Boeing stresses that it began developing the MCAS enhancement package over the past three months after issues with flight-control software, systems and pilot training were implicated early in the JT610 accident investigation. The enhancements were therefore already in development when ET302 crashed.

As well as helping the MAX to handle like the 737NG, the MCAS was introduced to decrease pitch-up tendency at elevated AOA. The changes in handling, which were found during testing in an extreme part of the flight envelope, were caused by the additional lift generated by the nacelles of the MAX's larger CFM Leap 1B engines, which are located farther forward than on earlier 737 models.

The first change, "and probably the most important," Sinnett says, "is that we compare data from left and right AOA

**Data from the ET302 flight data recorder shows that the crew attempted to counter the MCAS inputs (see red box) but were unsuccessful.**

sensors full-time and when the flaps are up—in a situation when MCAS would be armed. If they vary by more than 5.5 deg., the system will inhibit MCAS and the entire speed trim system for the remainder of that flight." If an AOA disagree of more than 10 deg. occurs between the sensors for more than 10 sec., it will be flagged to the crew on the primary flight display (see box, page 24).

"In addition, as a customer option, we provide the capability to display raw data for AOA," Sinnett adds. "Most airlines do not select this because it is purely supplemental information."

In the current MAX design, the MCAS receives input from only one sensor during each flight. The left and right sensors alternate between flights, feeding AOA data to the flight-control computer and the MCAS. The single-point-of-failure potential of the original design was criticized in the wake of the Lion Air accident, where erroneous data appeared to activate the MCAS.

Boeing also confirms that the system will allow only one trim application for each new trigger of the MCAS by an elevated AOA event. The revision means the MCAS can never command more stabilizer input than could be countered by the crew pulling back on the control column. The company says its failure analysis of the system indicates there are no known or envisioned failure conditions in which the MCAS will provide multiple inputs.

In the original design, the MCAS trims nose down up to 2.5 deg. by moving the horizontal stabilizer at 0.27 deg./sec. for 9.2 sec., stops for 5 sec., then trims nose down again for 9.2 sec. and continues to do so until the trim reaches the stabilizer travel limit or the crew intervenes. Boeing reemphasizes that the crew will retain the capability to override the flight-control law using electric or manual trim, or by following the existing runaway stabilizer procedure and



using the cut-out switches, as reinforced in the Operations Manual Bulletin issued on Nov. 6, 2018.

The third major change is that "there is no situation in which more stabilizer input can be provided by MCAS than there is control column authority for pilot response," Sinnett says. "The control column will always be able to override MCAS inputs. These are very important changes."

Training programs will now include an updated level-B computer-based training program to enhance pilot understanding of the 737 MAX speed trim system, including the MCAS function and associated crew procedures and software changes. Alterations are also planned for the Airplane Flight Manual and Flight Crew Operations Manual as well as new notes for the speed trim fail checklist in the Quick Reference Handbook. The Airplane Maintenance Manual and Interactive Fault Isolation Manual are being revised as well.

"We are working with customers and regulators around the world to restore faith in our industry and also to reaffirm our commitment to safety, and earning the trust of the flying public," Sinnett says.

Among the most criticized aspect of MCAS design is the single-string-failure potential of MCAS AOA input. The senior Boeing executive says the original design was based on a standard industry process of hazard classification, which defined the potential failure as one that could be mitigated "very quickly by a trained pilot using established procedures"—in this case, the stabilizer runaway checklist.

"In this particular case, because we don't know yet what the ultimate cause is, we can look at that one link in the chain and say we know ways to update the MCAS functionality to make it more robust, and that is what we are doing," the executive says. "Certification standards say a runaway stabilizer has a memory procedure associated with it—despite all of that, we are looking at it and saying, 'We don't want to intentionally provide the pilot with that scenario again.' So in the design, we are using multiple inputs, even though in the original hazard classification, multiple inputs would not be required. We've seen two accidents, and we believe it is appropriate to make that link in the chain more robust."

Evidence from both 737-8 accidents suggests the chain's link was weak to begin with, as Boeing put too much stock in the pilots' ability to quickly troubleshoot multiple-failure scenarios. Investigators have found similarities between the ET302 and JT610 accident sequences, notably that repeated horizontal stabilizer nose-down inputs from the MCAS, which was being fed erroneous AOA data, is believed to have confused the pilots.

The interim report on ET302 confirms the pilots managed to diagnose uncommanded and unwanted nose-down inputs as runaway stabilizer and followed the proper checklist procedure by toggling the cut-out switches.

"The crew performed all the procedures, repeatedly, pro-

vided by the manufacturer but was not able to control the aircraft," Ethiopian Minister of Transport Dagmawit Moges says.

While the cutout switches were flipped, the pilots' entire sequence of steps raises some questions. Among them: Should they have reacted more quickly to the uncommanded stabilizer input, and how did their high rate of speed—the entire flight operated at 94% N1—affect the accident sequence?

Flight-recorder data shows that ET302's departure at 5:37:45 UTC was normal. Just after takeoff, the aircraft's two AOA vanes deviated. The left vane's value jumped to 74.5 deg. in less than a second, indicating a sharp nose-up attitude, compared to the right's value of about 15 deg. Moges says investigators have no evidence of foreign-object debris affecting the AOA sensor. The left-side stickshaker also activated.

The crew continued its climb-out, retracting the flaps at 5:39:45 UTC. Ten seconds later, the autopilot disengaged, arming the MCAS in the process. The system, reading the

## 737 MAX Flight-Control System Changes

	MANEUVERING CHARACTERISTICS AUGMENTATION SYSTEM	PROPOSED REVISED SYSTEM
<b>Redundancy</b>	Fed by data from one of two angle-of-attack (AOA) sensors; the source alternates on each flight.	Will compare data from both AOA sensors. If sensors disagree by more than 5.5 deg., system will not activate.
<b>Operation</b>	Commands 0.27 deg. of aircraft nose-down stabilizer deflection per second for 9.3 sec. per input—a total of 2.5 units of trim. Inaccurate data triggers the MCAS every 5 sec. until data is corrected or the MCAS disabled.	Commands 0.27 deg. of aircraft nose-down stabilizer deflection per second for 9.3 sec. per input—a total of 2.5 units of trim. Will provide one nose-down stabilizer deflection input per non-normal AOA event.
<b>Pilot Interaction</b>	Because the MCAS is attempting to increase the control force, the control column cutout switches are inhibited. Yoke-mounted electric trim switches interrupt the MCAS. STAB TRIM CUTOUT switches disable the MCAS.	Control column cutout switches inhibited. "System cannot command more stabilizer input" than pilots can counteract by pulling back on column, Boeing says. Yoke-mounted electric trim switches interrupt system. STAB TRIM CUTOUT switches disable system.
<b>Flight-deck Indications</b>	AOA DISAGREE flag and AOA indicator on primary flight display (PFD) are an optional add-on package.	AOA DISAGREE flag standard on PFD; AOA indicator option is available at no cost. If an AOA disagree occurs for more than 10 sec., it will be flagged on the PFD.
<b>Training</b>	No specialized training or details in MAX flight manual.	Boeing will provide flight manual bulletin and computer-based training detailing the system.

Source: Boeing

faulty AOA data, detected the aircraft was nose-high and moved the stabilizer from 4.6 units to 2.1 units in 9 sec. The aircraft stopped climbing and began to descend.

Aft control-column force is recorded, as are nose-up commands via control-column-mounted electric trim switches, moving the stabilizer to 2.4 units.

At 5:40:20, or 5 sec. after the nose-up commands stopped, the MCAS—still detecting the left-side AOA sensor's inaccurate data—adjusted the stabilizer to 0.4 units. At 5:40:28, the pilots interrupted the MCAS with electric trim inputs, adjusting the stabilizer to 2.4 units. Seven seconds later—or 35 sec. after the initial MCAS cycle began and nearly 2 min. after the stickshaker started—they hit the cutout switches.

The crew attempted to pull the nose up with aft column pressure for much of the next 2 min. At 05:41:46, the captain asked the first officer "if he could try [the nose-up trim inputs] manually," the report says. "The first officer replied that it is not working."

The left-side indicated air speed was 340 kt.; the right side was 20-25 kt. higher. The crew received an over-speed warning, asked to return to Addis Ababa and received clearance.

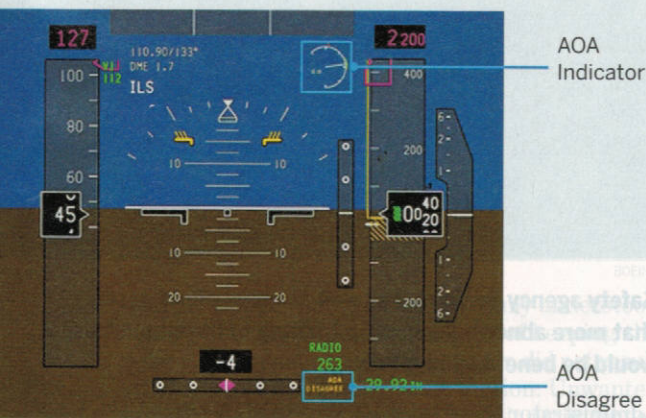


By 5:43:11, the stabilizer was down to 2.1 units. The crew apparently toggled the cutout switches back on, because two brief nose-up inputs moved the stabilizer to 2.3 units. Five seconds after the nose-up inputs, the stabilizer automatically moved nose-down to 1.0 unit in 5 sec. The aircraft began pitching nose down and crashed about 25 sec. later.

All parties involved in the probe agree that the MCAS factored into the accident, and that Boeing's planned changes will make the system less aggressive and more reliable. But the sequence of events from the first MCAS activation through the repowering of the stabilizer is being interpreted in sharply contrasting fashions.

Evidence reviewed by the Ethiopian-led delegation, which includes representatives from Boeing, the FAA, NTSB, the European Aviation Safety Agency and France's BEA, is clear, Moges says: The crew followed Boeing's published procedures.

Two sources with knowledge of Boeing's thinking tell Avi-



### Boeing MAX upgrades will make angle-of-attack warnings and indicators standard.

ation Week that the manufacturer disputes this, arguing that the pilots did not respond quickly enough and let the aircraft's nose drop too far before cutting off the automatic stabilizer input, instead of overriding MCAS with nose-up trim via the column-mounted inputs. As evidence, Boeing is pointing to the JT610 sequence, one source says. In that accident, the crew used the column-mounted inputs to counter MCAS nose-down inputs for about 7 min., or 1 min. longer than the entire ET302 flight sequence, before losing control.

Boeing's stabilizer runaway checklist does not state that the aircraft must be trimmed before the cutout switches are toggled. Trimming the aircraft should be second-nature, several pilots say, and is not something that needs spelling out on a checklist.

"Trimming is something you do constantly while hand-flying the aircraft," says one North America-based MAX pilot. "I do it without thinking about it, from nearly just after liftoff until right before we enter the flare. Whenever the airplane is slightly out of trim, I use the yoke-mounted switches to make an input. That's why it is surprising to me that the Ethiopian [crew] didn't use very much of the electric trim as the MCAS trimmed the nose down. To me, it would be the natural reaction, before you even realized what was trimming the nose down."

By not immediately recognizing the stabilizer runaway, the

crew was apparently left with fewer options. If investigators determine that the ET302 crew could not manually trim the aircraft once they stopped the MCAS because of the forces exerted on the stabilizer, both training and the checklist language will come under fire for not highlighting this risk. Conversely, the aircraft's high rate of speed may have put more downward force on the stabilizer, inhibiting the crew's ability to hand-trim.

The ET302 interim report includes two recommendations. Investigators called on Boeing to "review" the MAX's flight-control system and update it as necessary and urged global regulators to ensure the update "adequately" addresses known safety issues before the aircraft is cleared for operations.

As Boeing works to improve the 737 MAX flight-control software and 737NG-to-MAX transition training, other quarters are launching what is expected to be a lengthy and detailed examination of the FAA's certification processes—and the 737 MAX's approval specifically. The Senate aviation and space subcommittee on March 27 held the first of what will be multiple congressional hearings on issues raised by the accidents.

Acting FAA Administrator Dan Elwell assured senators that the FAA played a central role in the MCAS certification, and the in-service issues uncovered following the JT610 accident do not signal errors made during the system's design and risk analysis.

"The FAA was directly involved in the System Safety Review of" the MCAS, Elwell says. "The certification process was detailed and thorough, but, as is the case with newly certified products, time yields more data to be applied for continued analysis and improvement. As we obtain pertinent information, identify potential risk or learn of a system failure, we analyze it, find ways to mitigate the risk and require operators to implement the mitigation. And that is what has happened in the case of the 737 MAX."

Senators pressed Elwell over the role the FAA's Organization Designation Authorization (ODA) process played in the MAX's certification. Under ODA, FAA-vetted company employees verify that products meet certification requirements. This helps the agency keep certification projects moving faster, while ensuring they adhere to its regulations. Lawmakers expressed concern that the MCAS may not have been thoroughly vetted because it was part of ODA.

Elwell told the subcommittee that the FAA was in charge of verifying the MCAS early on in the aircraft's certification process but later delegated it to Boeing once the agency was confident the company had the expertise to manage it.

"As a new device on an amended type certificate, we retained the oversight of" the MCAS, Elwell says. As the ODA process for the MAX was refined "under very strict review," the MCAS was shifted to the manufacturer.

Elwell also clarified that the MCAS was not flagged by pilots as a relevant change from the 737NG during certification. The 737 MAX flight standardization board, which included 737NG pilots from multiple carriers, flew a 737 MAX simulator to compare the two models.

"After many scenarios and flights in all regimes, there was a consensus that there was no marked difference in the handling characteristics of these two aircraft," Elwell says. This, he explains, was the primary reason that more information on the MCAS was not provided in pilot training documents. ☐



# MAX Saga Spotlights Flight-Deck Human Factors

➤ TWO BOEING 737-8 ACCIDENTS CENTER ON PILOT REACTIONS

➤ CREWS LACKED CRITICAL INFORMATION; ABNORMAL-SCENARIO TRAINING URGED

Sean Broderick, Bill Carey and Ben Goldstein Washington

**D**etails emerging from investigations into two fatal Boeing 737-8 MAX accidents in five months are fueling a heated debate over whether the pilots involved were adequately prepared to face their inflight emergencies or simply could not overcome failure modes rooted in a flawed design. Either scenario implicates flight-deck human-factors shortcomings that will reverberate far beyond the software upgrades Boeing is counting on to help get the 737 MAX fleet flying again.

While the investigations into the Oct. 29, 2018, crash of Lion Air Flight 610 (JT610) and the March 10 Ethiopian Airlines Flight 302 (ET302) accident are ongoing, links between the two have been established. In each case, the flight crews battled to keep a new 737-8 aloft while the aircraft's Maneuvering Characteristics Augmentation System (MCAS) pushed the nose down by applying stabilizer trim. The MCAS, which was added to the 737 speed trim system to help the new model handle like its 737NG predecessor in certain flight profiles, relies on data from one of the MAX's two angle-of-attack (AOA) vanes. In each accident, investigators have confirmed the aircraft was getting unreliable data from an AOA vane, which triggered repeated MCAS nose-down inputs.

Boeing is developing a software upgrade that will prevent the updated system from activating if it is fed erroneous data (see page 24). It also gives pilots ultimate elevator authority by limiting the degree of automatic nose-down stabilizer. Additional training and updated flight manuals will also be provided. These changes will be part of safety regulators' demands to lift 737 MAX revenue-service operations bans that have grounded the 376-aircraft fleet since March 13.

The changes are a de facto admission that the MCAS needed improvement. Beyond that, questions about how well-prepared pilots were to deal with the system's failure remain paramount in many circles. Boeing did not include any MCAS information in 737 MAX flight manuals, which some point to as an egregious oversight. It was only after JT610 that Boeing provided pilots with extensive details about handling the MCAS.

Many pilots say that though they do not agree with Boeing's philosophy of keeping the system in the background, they acknowledge Boeing's logic that an MCAS failure would be recognized as uncommanded stabilizer input and managed via the common "stabilizer runaway" checklist was reasonable. The checklist, which is the same on the 737NG and MAX and includes a step that cuts power to the stabilizer, is supposed to be common knowledge for airline pilots.

"Pilots of large aircraft are trained from Day 1. When the pitch of the aircraft is doing something you're not telling it to do, you do a runaway pitch trim checklist," Acting FAA



**Safety agency personnel as well as many pilots agree that more abnormal-scenario training in the simulators would be beneficial to pilots.**

Administrator Dan Elwell, a former airline pilot, told a U.S. Senate subcommittee during a March 27 hearing about the MAX. "In every plane I've ever flown, it's called a memory item. You're not fumbling through books. It's a time-critical procedure, and you go to that."

The European Aviation Safety Agency Executive Director Patrick Ky, speaking to European Parliament members on March 19, said the procedure "is not that complicated." But the fact that it was not followed by the Lion Air crew suggests they were confused. "If they knew what was really happening, they would not have done what they did, and they would not have crashed," Ky said.

The ET302 crew had the benefit of knowing about the MCAS, and investigators determined that they followed the prescribed procedure—at least in part. The MCAS activated and pushed the aircraft's nose down. The crew responded with manual inputs via column-mounted trim switches, which countered only a portion of the MCAS nose-down input. The automated system, still receiving erroneous data, activated two more times, dropping the nose even more. After the third MCAS nose-down input, the crew toggled the cutout switches. Struggling to maintain altitude, they turned the system back on, which triggered the MCAS again.

Investigators are looking closely at how the ET302 crew reacted, and why they reactivated a system that they identified as central to their problem. One possibility: With power to the stabilizer cut off, they would have needed to move it by cranking a center-console-mounted wheel attached to cables and pulleys. This may have taken more time than they believed they had, or been too difficult, so they opted to reengage stabilizer power and try the column-mounted switches.





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Another possibility: They may not have fully understood what they were facing. Boeing's approach of keeping the MCAS in the background means its activation did not result in any cockpit warnings. Boeing's assumption: Unwanted nose-down inputs, signified in part by a spinning trim wheel, would alert pilots to a runaway stabilizer and prompt them to execute the checklist.

"If I had been flying a MAX with stickshaker activation at liftoff after the Lion Air accident, shutting off the trim would have been accomplished in a matter of seconds, not minutes," says one U.S.-based MAX pilot. "I probably would have activated the stabilizer trim cutout switches before the gear was even up. Why that didn't happen on the Ethiopian flight is a mystery to me."

The stickshaker warning, or artificial vibrating of the control column that signifies a stall is imminent, activated on both JT610 and ET302 because of the faulty AOA data. Meant to alert pilots of a problem, it can be more of a distraction than a help in certain scenarios, the MAX pilot says.

"Not only would the noise mask the operation of the trim [wheel], it is such a significant warning that it would command a lot of attention," the pilot says. "Ultimately, it is not telling you anything useful, but it makes recognizing the trim runaway more difficult, especially since the trim was not continually running."

The two MAX accidents underscore a larger concern: Is automation beginning to supplant, instead of augment, basic flying skills? While airlines have long used it safely, pilots who typically fly with automation who were involved in accidents "made errors when confronted with an unexpected event or [when] transitioning to manual flying," the Transportation Department Inspector General's office found in a 2016 report to Congress.

"As a result, reliance on automation is a growing concern among industry experts, who have questioned whether pilots

receive enough training and experience to maintain manual flying proficiency," Transportation Department Inspector General Calvin Scovel said in the March 27 hearing. The initial results from the ET302 accident "raise concerns about pilots' abilities to recognize and react to unexpected events," he added.

The FAA now requires that Part 121 pilots be trained in specific abnormal flight conditions, including stall and upset recovery and loss of reliable airspeed, and that training on the responses be performed in full-flight simulators. But the recent 737-8 accidents have raised questions about the availability and capabilities of simulators, Scovel says. According to the FAA, "existing simulators do not fully replicate the 737 MAX aircraft, and no U.S. airline currently has a MAX simulator," he says.

Most airline standard operating procedures "recommend and encourage" using full automation to control an aircraft for safety and efficiency reasons, observes Hassan Shahidi, Flight Safety Foundation (FSF) president and CEO. Automated systems can improve pilots' management of the flightpath, particularly during reduced weather minima, relieving them from repetitive tasks. But by depending on automation, they revert to monitoring the system rather than actively flying the aircraft. There are various theories about how complacency affects pilot performance, says Shahidi, a former Mitre Corp. senior executive who started at FSF in January.

With all of the advantages it confers, automation is not a substitute for the function of the pilot, who ultimately is responsible for flying the aircraft, says Shahidi. With respect to pilot training, "there needs to be sufficient understanding for the basis of the automation—why there is automation in the first place—and what happens with partial or full-use" of a system, he says. Also, pilots should understand the importance of monitoring an expected function so they can take timely and corrective action if there is a malfunction.

Training that focuses pilots on abnormal situations is important, whether in a simulator or non-simulator environment, Shahidi advises. For example, pilots who fly with the autothrottle engaged, even in small aircraft, may lose the habit of regularly scanning the speed indicator. When the autothrottle disengages for some reason, the pilot may not readily notice or react to even large speed deviations.

"Automation has the potential to cause significant issues if it is misunderstood," says Shahidi. "Poor automation can reduce the pilots' situational awareness and create significant workload as they are trying to figure out what the automation is doing, especially if the system fails. This certainly can lead to an aircraft getting into an undesirable state from which it is difficult or sometimes impossible to recover."

The FSF issued a position paper on pilot training and competency in March 2018 saying the commercial aviation industry has reached a "crossroads" in determining how pilots should be trained and mentored and questioning whether the current approach can produce a "sustainable quantity and quality of pilots" for the expected future demand. Boeing has forecast a need for 790,000 new civil aviation pilots over the next 20 years. The Asia-Pacific region leads demand with a requirement for 261,000 new pilots over that time, the manufacturer predicts.

Shahidi concurs when asked if there is a need for more standardized pilot training across airlines that have different standard operating procedures and training requirements beyond what is minimally required by aviation au-



thorities and manufacturers.

"Moving forward, especially in light of the fact that we're looking at significant demand for new pilots in many of these regions, it is important to harmonize the level of training that is required," he says.

Among the recommendations the FSF white paper calls for are "competency- or evidence-based" training programs that are not solely hours-based and for maximized use of simulation devices.

Pilot performance criteria should be universally recognized, and the International Civil Aviation Organization tapped to define guidelines for the performance required of flight academies.

Shahidi points to the role of what he calls nontechnical competencies of communications, analysis, problem-solving, decision-making and leadership in piloting an aircraft. "It is not just understanding [which buttons to push] or disengage, but—as part of a holistic approach to training—these basic skills are important," he says.

Fundamentally, mastering these skills is both more realistic and more valuable than practicing scores of failure-scenario combinations.



STEPHEN BRASHEAR/GETTY IMAGES

**MAX software changes include incorporating data from both nose-mounted AOA sensors.**

that includes 18 recommendations. Much of the report's focus is on how automation is both helping and hindering pilots. The anticipated guidance is expected to address several recommendations, including one on creating policy that airlines can integrate seamlessly into their own operations.

"The policy should highlight and stress that the responsibility for flightpath management remains with the pilots at all times," the report says. "Focus the policy on flightpath management, rather than automated systems. Note that this policy would contain what has previously been named an 'automation policy' and would be broader, to emphasize flightpath management." ☛

"We are not trained in many potential emergency situations," says the U.S.-based MAX pilot. "But we are trained to fly the airplane, prioritize, work together and diagnose whatever problem is facing us. In fact, I think just about every diversion I've had for mechanical problems has been for something we did not train for."

The FAA is working on guidance that stems from a 2013 working group report on flightpath management system usage

## Airbus Takes Aim at Inconsistent Pilot Training Quality

➤ THE PILOT SHORTAGE IS BOTH QUANTITATIVE AND QUALITATIVE

➤ THE AIRFRAMER ESTABLISHES A CADET PROGRAM

**Thierry Dubois** Toulouse

**A**irbus has created an ab initio pilot training program and will implement it in its global network of partner flying schools. The plan signals rising concerns about the varying levels of pilot training by country. The airframer is striving to standardize initial training, although national authorities have the final say.

Airlines face a pilot shortage created by pilot retirements and escalating air traffic. Thus far, the focus has been on the quantitative challenge. New academies and career programs are targeted at increasing the output of pilots but are up against issues such as instructor capacity and financing. Airbus forecasts demand for 540,000 new pilots over the next 20 years.

Beyond the numbers, a qualitative problem is becoming a concern, according to Jean-Michel Bigarre, head of global flight training at Airbus. "A

looming pilot shortage is coupled with variation in the level of training worldwide," he tells Aviation Week.

National authorities lack uniformity in pilot-training regulation. Airbus safety experts also see "strange things in poor countries where air transport is growing very fast—suspiciously quick pilot qualification and fraudulent flight-hour accounting." They are addressing the problem at the airline level. Especially for Asian carriers, it is useful to continue giving information on weather issues, they say. For example, a video was created recently to reexplain operations in convective conditions in a straightforward manner. With the massive demand for flight crew, "the aviation industry cannot afford that discrepancy any longer," says Bigarre.

A manufacturer should not only deliver aircraft it also should take care of their being efficiently and safely oper-

ated, Bigarre notes. The company has long established a "flight training reference" that recommends a global harmonized standard for pilot training. It defines prerequisites for achieving type rating. "In essence, cadets have to fulfill specific prerequisites at every stage of their pilot training from ab initio to type rating. If a prerequisite is not met, then the cadet cannot move on to the next level," he explains.

Airbus is adopting a "lead by example" approach. The national authority of a pilot-training organization is responsible for approving its programs. "Our implementing a program with this standard is encouraging the authority to follow us and raise the bar at other schools," says Bigarre.

Airbus describes its ab initio training as competence-based, focusing on the development of key pilot technical and behavioral skills. "We look at the pilot's ability to understand an exercise in an operational environment," says Bigarre. A cadet who passes the ab initio curriculum exams has the prerequisites documented in the Airbus flight-training reference.

Escuela de Aviacion Mexico (EAM), a partner flying school in Mexico City, began training pilots under the new scheme in January. In May, Airbus