Publication of the Boeing 737 MAX Proposed Airworthiness Directive and Recent Movements for Resuming Its Operation

Yoshihiro Fujimaki, Japan International Transport and Tourism Institute, USA

1. Recent Actions of the Federal Aviation Administration (FAA) for the Boeing 737 MAX Aircraft Crash Accidents

The previously published report, "Historical Background of the Delegation System for Aircraft Certification in the U.S. and its Status after Boeing 737 MAX Accidents," included an outline of Boeing 737 MAX series aircraft accidents in 2018 and 2019, and the FAA's response through May 2020. [1] The following describes the FAA's actions since then.

Firstly, the FAA conducted flight tests with Boeing for 3 days, during June 29th to July 1st, of the aircraft with upgraded flight control systems, which were the root cause for the accidents. After completing these flight tests, the FAA required the following mandatory tasks for resuming operations. ①Evaluate data obtained from the flight tests. ②Examine additional training requirements for pilots by the FAA's Flight Standardization Board (FSB) and Joint Operations Evaluation Board (JOEB), which includes experts from Canada, Europe and Brazil. ③The FSB is to issue a report after obtaining public comments. ④Boeing's final design documents, which show the design changes made to comply with requirements, are to undergo evaluation by the FAA. Furthermore, the Technical Advisory Board (TAB), which includes experts from U.S. Air Force and NASA, must provide an additional review of Boeing's documents and issue a report. ⑤Issue airworthiness directives (AD), which dictate design changes, etc. Finally, ⑥lift the emergency order that mandated the operation ban from March 13th, 2019. In addition to these, the FAA emphasized that they will lift the emergency order only if they can ensure that aircraft meet the certification standard.

Regarding ⑤ (issuing AD mandating design changes) mentioned above, proposed AD were released on the FAA website on August 3rd, then were officially published on the Federal Register on August 6th. [1]

The length for accepting public comments on the proposed AD is 45 days, with the deadline set for September 21st. Afterwards, the FAA will conduct a final review of these comments. In the next section, the contents of the published proposed AD will be explained, taking into account the FAA's tentative summary of the reviews[2], which were released at the same time.

2. The Content of the Proposed AD for Boeing 737 MAX

According to the published proposed AD, the root cause of the two accidents is considered to be a single Angle of Attack (AOA) sensor which incorrectly sent information to the flight control system that the pitch angle was too high, making it difficult for the pilots to control their aircraft as the Maneuvering Characteristics Augmentation System (MCAS) repeatedly actuated the horizontal stabilizer to pitch down, which resulted in the planes crashing.

In order to solve this problem, the FAA proposed four design changes in the proposed AD. They are ① an update of the software for the flight control system, ② an update of the software for the display system in cockpits, ③ changes of pilot operating procedures in the flight manual, and ④ a

change in the placement of wiring related to operating the horizontal stabilizer.

In addition to these four design changes, before resuming operations of individual aircraft, the FAA proposed for operators ⑤ to conduct operational tests of AOA sensor systems, and ⑥ to perform readiness flights.

Furthermore, the FAA proposed ⑦ to include stricter requirements on the Minimum Equipment List, which describe the conditions that aircraft can still depart when having partial system issues.

Beyond 40 FAA engineering employees conducted evaluations over more than 60,000 hours, including the analysis of more than 4,000 hours of Boeing test flights and about 50 hours of FAA test flights (including tests through a simulator). Based on these results, the FAA tentatively concluded that the aircraft can effectively address safety issues. The following sections will detail each design change and how system issues should be improved after they are made.

2.1 The Flight Control System's Computer Software Update

The computer software update of the flight control system is aimed to prevent MCAS from malfunctioning when incorrect information is sent from a single AOA sensor.

Specifically, while the existing software activated the MCAS by relying on data from a single AOA sensor, the updated software initiates the MCAS using data from both AOA sensors.

Moreover, the updated software compares the two AOA sensor data and detects any defects. When it receives differing data over the threshold of acceptable discrepancies, subsequent MCAS functions become inoperative, and it sends a signal to the cockpit to display that it is nonfunctional.

Furthermore, in order to prevent the MCAS from repeatedly actuating the horizontal stabilizer, MCAS activation was changed to only respond once per high pitch angle data sent from AOA sensors. Which is to say, MCAS can only activate again after the aircraft pitch angle is lowered back down.

In addition to these, while the existing software did not have a limit in how much the MCAS could actuate the horizontal stabilizer, the updated software caps this function in order for pilots to be able to maintain control using the control column, even when the horizontal stabilizer had been actuated by the MCAS.

2.2 The Cockpit Display System's Computer Software Update

The computer software updated on the display system in the cockpit is aimed to warn pilots about possible AOA sensor issues when more than a certain degree of differences are discovered between data from the two AOA sensors. Although this waring was not installed to some manufactured aircraft in the past, the updated software has implemented this function on all subsequent aircraft. While a loss of this warning itself is not unsafe, because pilots are required to rely on this function according to the operating procedures detailed in the proposed AD, mandating software updates has been proposed.

2.3 Changes of Pilot Operating Procedures in the Flight Manual

The changes of pilot operating procedures in the flight manual are aimed to bolster pilots' abilities to recognize and deal with the effects of flawed horizontal stabilizer responses and/or possible malfunctioning AOA sensors.

Firstly, in order to reduce a pilot's workload when an airspeed indicator's reliability is in question, procedures were changed, including adding ways to determine a reliable airspeed indicator without the use of a reference table, improving go-around procedures to allow increased use of automation, adding protocols to avoid sending incorrect altitude information to traffic control, and introducing incorrect AOA sensors as a possible cause of airspeed indicator unreliability..

Secondly, the criteria for using the checklist regarding horizontal stabilizer runaway was revised. As a result, cases for when a horizontal stabilizer is continuously activated without command and when it operates inappropriately for the flight conditions were included. Guidance for trimming a horizontal stabilizer manually was also included in the checklist, along with procedures in the case of its malfunction.

Thirdly, due to the flight control system computer's design

change described in Section 2.1, where the MCAS's functions will become inoperable when the both AOA sensors' inputs differ, a checklist to continue flying the aircraft when a trim function is inoperative was added.

Fourth, a checklist was added for when the autopilot function cannot setup the trim of a horizontal stabilizer properly. Although an existing design has a warning light installed to alert pilots that autopilot cannot appropriately set up the trim with the horizontal stabilizer, the checklist provides additional information for pilots.

Fifth, a checklist was added for when a warning light is activated due to a difference in both AOA sensor inputs. In this case, pilots are to go through the checklist mentioned in the first point, regarding actions to take when the airspeed indicator may be unreliable.

As for the sixth point, a checklist was added for when warning lights turn on due to a difference in the readings from the right and left altimeters. A procedure for confirming whether the warning lights of airspeed indicators are illuminated at the same time, and further steps to complete subsequent descent and landing of the aircraft were added.

Finally, a checklist was added for when warning lights turn on due to differences in the readings from the right and left airspeed indicators. In this case, pilots are to go through the checklist mentioned in the first point, regarding actions to take when the airspeed indicator may be unreliable.

2.4 Change in the Placement of Wiring Related to Operating the Horizontal Stabilizer

The change to the placement of the wiring for operating the horizontal stabilizer was aimed to fix a part of the wiring route that was found to be noncompliant under the FAA's review. Specifically, putting physical distance between the wiring for the trim arm of the horizontal stabilizer and that of the trim control was required.

2.5 Operational Tests of the AOA Sensor System

In order to ensure that both AOA sensors of every aircraft operate appropriately, the FAA proposed for operators to perform tests of the AOA sensor system for each aircraft before resuming operations.

2.6 Readiness Flights to Resume Operations

Considering that aircraft operations have long been regulated and the significance of the control system, it has been proposed to require readiness flights for each aircraft after design changes have been made before they resume operations.

2.7 A Stricter Minimum Equipment List

While previously the Minimum Equipment List, which specifies steps to follow before departure is permitted when a part of the aircraft system malfunctions, allowed aircraft to depart when one flight control system computer was working fine, it now has become stricter by requiring both flight control system computers to be working without issue before departing.

3. Recent Movements to Resume Operations and the Future Course of Events

After the FAA completed flight tests in early July, the European Union Aviation Safety Agency (EASA) announced on their website on September 11th that they had also finished flight tests. [3)]

On the other hand, regarding required tasks needed to resume operations that still remain to be completed, the public comments to be gathered for ③ the reports to be issued by the FSB have not yet been started as of the middle of September. It is expected to take at least a month to conduct and review public comments. Thus, operations are expected to resume during or after the second half of October, at the earliest.

Furthermore, the report published by the US House Committee on Transportation and Infrastructure on the September 15th[4)] pointed out strictly of undue pressure within the Boeing company on schedules, and insufficient FAA oversight. This might also affect the timing of resuming operations.

References

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