

**Written Testimony to the Transportation and Infrastructure Committee of the United States House of Representatives on the Boeing 737 MAX Return to Service Hearing by Matthew Kiefer**

**11 December 2019**

Good morning Chairman DeFazio, Ranking Member Graves and Members of the Committee. Thank you for having me here, it is my honor to participate on this panel today.

First I'd like to introduce myself. My name is Matt Kiefer and I have been working in the aviation industry for over 25 years. In that time I have worked in aircraft maintenance on fighter jet aircraft as well as general aviation aircraft. I have worked as a flight test engineer and been responsible for all flight test data acquisition at an aircraft modification company as well as system design and integration for aircraft modification programs. I have worked for the U. S. Department of Defense as a lead systems engineer for a Navy aircraft program and been responsible for system safety engineers working across several different Air Force programs. I have also been an Aerospace Engineering Officer for the Navy Reserve for over ten years where I specialize in combat forensics analysis of aircraft battle damage. Currently I am working in the Air Force airworthiness office where I am responsible for some aspects of policy and manage the division's computer systems to include the one that processes airworthiness reviews. I am also a Lieutenant Commander in the Navy reserve attached to an engineering unit that supports NAVAIR. Additionally I am an instrument rated private pilot with over 600 flight hours in general aviation aircraft.

I was asked by the FAA to participate on a team known as the B737 MAX Technical Advisory Board otherwise known as a TAB. This is an independent team of aviation industry experts with no past involvement with the B737 MAX development or certification. Our team is made up of experts from various specialties including test pilots, aerospace engineers and chief scientists with backgrounds in flight controls, flight operations, simulators, human factors, computer systems and software, flight standards and safety. These experts come from the FAA, NASA, the Air Force and the Volpe Center. We were chosen for our ability to take a look at the B737 MAX changes objectively with fresh eyes because we are independent from Boeing or the FAA certification effort of the aircraft. Our team was chartered to examine and review the changes Boeing is making to the B737 MAX flight control system and make recommendations back to the FAA as to the suitability of those changes before the aircraft is returned to service.

Our team started our work with some teleconferences where we became acquainted with the Boeing team and the 737 MAX airplane and its systems. We then had our first face-to-face meeting at the Boeing facilities in Seattle in May where we spent time working with the Boeing engineering department. This meeting started off with encouragement from FAA and Boeing management to dig into the systems and scrutinize the work that has been done to develop the solutions to the problems that led to the two accidents and give our unbiased opinion as to the suitability of those fixes.

At this meeting we started by learning more about how the speed trim system and MCAS function as well as having discussions on various failure modes with the system. We were then given in-depth debriefings on what happened with the two mishap aircraft including information on the Lion Air flight that occurred the day before the first accident. After that we were given detailed briefings with discussion on the changes that had been developed for MCAS.

Our team was given an opportunity to fly in the B737 MAX eCAB which is the engineering development simulator at the Boeing engineering facility. Many of our team members, both pilots and engineers alike got an opportunity to fly the simulator with the old software and the new software. We were able to experience the accident scenarios and were able to observe aircraft behavior with MCAS operating properly as well as how the aircraft handles with MCAS disabled.

Boeing engineers sat down with several of the engineers on our team to go over the software development and certification for the flight control system. These sessions consisted of deep dives on how MCAS was developed as well as a look at how the changes are being implemented. Time was also spent by some of the team members reviewing aspects of the flight manual and training given to pilots of the B737 MAX.

During these meetings, which included multiple online conferences and two face-to-face meetings at Boeing, our team had the full cooperation of the Boeing engineering and flight test staff as well as good participation from the avionics sub-contractor. After these meetings, briefings and demonstrations the team gathered to assemble our findings and recommendations. Some of these we have determined are necessary before returning the aircraft to service. These recommendations/action items are being actively tracked internally to the TAB and with Boeing and the FAA. All recommendations that the team made for return to service have either been addressed and closed or are presently in work. The TAB is still working with Boeing to accept products to close the remaining action items. Once all of this work is complete the TAB will present a final report to the FAA.

There are four main changes to the B737 MAX flight control system software that have been developed to prevent future accidents like the ones that happened with the Lion Air and Ethiopian Air flights. They include the following:

1. Angle of Attack (AoA) comparison – an addition to MCAS that will now compare readings from both angle of attack sensors on the aircraft. If there is a difference of more than 5.5 degrees the speed trim system will be disabled. Also included in this change is something known as a “mid-value select” which uses data from both sensors together to create a third input that will help to filter out any AOA signal oscillatory failures or spurious sensor failures. This modification will prevent MCAS from commanding nose down trim when a single AoA sensor reports a false AoA as it happened in the two accident flights.
2. MCAS resynchronization – this change will account for manual electric trim inputs made by the pilot while MCAS is activating. It will track whatever input the pilot makes and return the pitch trim to that setting when MCAS retracts back to normal.
3. Stab trim command limit – is an addition that will limit the maximum nose down trim that the automatic flight control system can command to prevent the pitch trim from reaching an uncontrollable situation.
4. FCC monitors – software monitors have been added to the flight control computers that will cross check pitch trim commands against each other. If a difference is detected by these monitors the automatic trim functions are disabled. This protection helps prevent erroneous trim commands from a myriad of causes that could occur in the automatic flight control system.

These design changes in the software that controls the automatic pitch trim features including MCAS should prevent angle of attack sensor failures from causing the pitch trim to operate when it should not. Further, they should prevent the trim from activating erroneously for other reasons as well.

I would like to note that all along through our team's progress we have gotten nothing but assistance and courtesy from Boeing. At no time have any of our members been pressured to reach any predetermined conclusions nor were we encouraged to operate according to a timetable or schedule. Conversely we have been told by the FAA and Boeing leadership to emphasize safety and diligence in our research.

The TAB still has work to do to complete our assessment of the changes to the B737 MAX systems as we are awaiting more information on the development assurance, testing of the software, final safety assessments and final training for aircrew. Pending the team's determination that the remaining review results meet our expectations, our team feels that the changes made to the flight control software in the B737 MAX should vastly improve the safety of the aircraft, in keeping with the highly successful safety record of the previous models of the Boeing 737.