**Statement of G. Michael Collins,**

**Former Aerospace Engineer**

**Federal Aviation Administration**

**To Sen. Maria Cantwell, Chair, Senate Committee on Commerce, Science, and Transportation**

First, I want to offer my condolences to the family members and friends of those who died in the two tragic 737MAX accidents.

I am a retired FAA Aerospace Engineer with 29 and a half years' experience in the FAA as a propulsion specialist; 5 years' experience in Boeing Commercial Airplane Company; and several years' experience in other safety critical industries including nuclear and non-nuclear power plant design. Although I am not representing anyone else, I know I have the support of many of my past coworkers at the FAA.

As the committee reviews the FAA oversight of the 737MAX certification, it is an opportunity to review the overall issue of FAA oversight and the safety culture of management in the FAA's Aircraft Certification Service. When I first started working at the FAA in 1989, the management I worked for had a much different safety culture than today. In my early years at the FAA, I found management very supportive of engineers in the evaluation of proposed airplane design changes. Management supported engineers when they identified features that did not comply with the Federal Aviation Regulations (FARs). I was taught the FARs defined the minimum level of safety for airplane designs. If we discovered a design that did not comply, we identified the issue to our managers and the applicant's Designated Engineering Representative (DER). We then all worked with the applicant to help them develop design changes that resulted in a design that all the FAA specialists agreed met the minimum safety standard defined in the FARs. It was a much more a collaborative environment than what exists today.

There were some controversial issues then too, but typically the final FAA position was something everyone on the FAA team, engineers, and managers alike, could agree was an acceptable method of compliance to the FARs, a consensus decision.

After the investigation of the TWA 800 accident (during which I represented the FAA Aircraft Certification Service on the NTSB Systems Team) and shortly after the 2001 Fuel Tank Safety rule was issued, I saw a significant shift in management. It was an erosion of the safety philosophy. FAA management shifted away from supporting FAA technical specialists (FAA aerospace engineers) in favor of industry positions. This shift continued until I retired in July 2018. The most recent and clear example of this erosion in safety culture that I witnessed was regarding the minimum level of safety debates on how to protect the rudder controls on the 737MAX from catastrophic damage from an uncontained failure of the new engines.

<u>737MAX Rudder Control – Protection from Catastrophic Failure due to Uncontained Engine Failure</u>

I was not working on the 737MAX at the time, so I was not involved in the original discussions of the rudder control design. I became involved as one of four members on the Safety Oversight Board (Board) when a safety concern (report) was submitted to the AIR Safety Review Process. The safety reports were submitted to the Board with the submitter's identifying information removed ("de-identified").

The Board reviewed the submittal which included the Issue Paper used to document the agreement with the applicant on the means of compliance the applicant would use to the relevant FARs. In this case, the Issue paper was signed by two managers, but all 7 FAA technical specialists (aerospace engineers) and the project pilot disagreed with the method of compliance described in the issue paper and therefore did not concur. Three FAA aerospace engineers did sign the issue paper, but their function was administrative to ensure the issue paper was coordinated with the appropriate technical specialists.

The SRP Oversight Board determined the issue was complex enough that we would identify a Subject Matter Expert (SME) Panel to review the SRP report and make recommendations on the safety concern to the Board. The SME Panel members were selected based on their expertise in the subject and were chosen from various FAA offices so many were not involved in the original discussions. All recommendations from the SME Panel, as well as from the Board, are required by the SRP process to be consensus-based decisions. That is, the final report and recommendations from the SME Panel, and the Board, must be something all

members of the respective panel or Board "can live with." It is not based on majority rule.

The SME Panel included four FAA aerospace engineers and two FAA managers. The consensus-based recommendations of the SME Panel include a statement that the method of compliance directed by FAA Management and included in the issue paper does not comply with the associated Federal Aviation Regulations (FARs). The method of compliance did not meet the required minimum level of safety. Note that the report also included recommendations on design changes that would result in an acceptable means of compliance to the associated FARs.

The SRP Oversight Board, which was comprised of two aerospace engineers and two managers, agreed with the SME Panel report, and forwarded it to the responsible FAA Aircraft Certification Service Division/Directorate manager ([redacted]. The FAA Division/Directorate manager responded later to the Board that the Transport Airplane Directorate (TAD) "considered the Board's recommendations and believes that the TAD met the Board's intent by following existing FAA rules, orders and procedures related to certification and delegation activities." The SRP Oversight Board determined the Division/Directorate manager did not implement the Board's recommendations and therefore, in accordance with the SRP Process, the Board forward the Board/SME Panel's recommendations and the Division/Directorate manager's response to the Deputy Director, Aircraft Certification Service, AIR-2, for his/her information.

Therefore, when considering the non-concurrences on the issue paper, the SME Panel report and the SRP Oversight Board members recommendation; a total of at least thirteen FAA aerospace engineers, one pilot and at least four FAA managers disagreed with the method of compliance other FAA managers allowed Boeing to use. This was NOT a consensus decision.

Note the SRP report said the Airbus A320neo rudder control had a similar design to the 737MAX. The submitter said the FAA certification team for the A320neo had reached agreement with EASA and Airbus that Airbus would change the design to a compliant "fly by wire" rudder control design and implement the new design into production after certification. Although FAA did not require such a design change through a time-limited partial grant of exemption, information available on the internet[1] confirms Airbus is proceeding with the design change.

[1] https://www.flightglobal.com/air-transport/airbus-switching-a320neo-family-from-mechanical-to-electronic-rudder-control/143203.article

Information I have received from others confirms the new Airbus design will fully comply with FAA regulations and policy for protection from catastrophic failure due to uncontained engine failure.

737MAX Fuel Tank Surface Temperature

Another issue submitted to the Safety Review Process on the 737MAX project was where an agreement was made with the applicant using an issue paper to allow fuel tank temperatures above the maximum temperature allowed by the FARs. In this case, the technical specialist (aerospace engineers) working the issue did all sign the issue paper, indicating their concurrence. The issue paper document agreement on a finding that the applicant's method of compliance was an "Equivalent Level of Safety" to the normally accepted means of compliance. However, an employee submitted a safety concern about the decision in the issue paper to the SRP. The SRP Oversight Board designated a new, unique, SME Panel to review the safety report and make recommendations to the Board. The SME Panel agreed with the SRP submitter that the issue paper agreement was not an equivalent means of compliance with the associated FAR and made several recommendations. The SRP Oversight Board accepted the SME Panel report and forwarded it the responsible Division/Directorate manager (again, [redacted]). I do not have firsthand knowledge of how the Division/Directorate manager responded as there had not been a response when I left the SRP Oversight Board prior to my retirement. However, information I received from others indicates no change was made to correct this non-compliant design.

737MAX Fuel Pump Circuit Protection

An issue that was not raised in the SRP is related to the 737MAX fuel pump electrical circuit protection. FAA fuel pump ignition source prevention requirements essentially require ground fault interrupter (GFI) or similar fast acting circuit protection with active faulty detection and annunciation of failures on fuel pump power circuits. This requirement is to prevent electrical arcs in fuel tanks from failures of the high-power fuel pump wires that have previously occurred. An FAA manager ([redacted] provided guidance to Boeing without going through the issue paper process for certification of a GFI installation that was contrary to FAA published policy in Advisory Circular 25.981-1C and in a "generic" fuel pump issue paper on the Transport Airplane Issues List. The manager told the applicant they could consider fuel in the area between the fuel

pump and the housing the fuel pump is installed in as a flame or spark barrier. This guidance was given by the manager despite FAA technical specialists reminding the manager that there were known failures on a similar fuel pump installation (L-1011) that experienced a wiring failure inside the pump and burned a hole through both the fuel pump and the outer housing. (Fortunately, that L-1011 event did not result in a fuel tank explosion because the pump housing was under liquid fuel so there was not a flammable air-fuel mixture exposed to the flame.) The FAA manager told the applicant that taking credit for fuel in the space between the motor and housing, which is typical for Transport Category fuel pump installations including the L-1011 installation, 'was not prohibited by the AC.' This may be a factual statement, but the issue of the of protecting against such a design is listed in the lessons learned. Also, many design issues are not "prohibited" by advisory circulars because not all designs are considered. Therefore FAA procedures requires using the formal Issue Paper process when providing guidance that is not included or is contrary to the guidance in advisory circulars. Providing such guidance by an email is contrary to the FAA procedures and practices.

At the same time, the FAA required Airbus to modify their fuel pump GFI installation before certification of the A320Neo. Before the FAA required modification, the proposed A320Neo GFI installation was very much like what the FAA manager allowed to be certificated on the 737MAX.

## 787 Lithium-Ion Battery Containment

Before the AIR Safety Review Process was implemented in mid-2015, there were other examples of FAA management accepting applicant's positions over the concerns of FAA technical specialists, the FAA's aerospace safety engineers. For example, during initial certification review of the new technology 787 lithium battery system design the certification of the 787, an FAA technical specialist determined the lack of a fireproof enclosure could result in catastrophic failure due to uncontrolled fire from the battery. He proposed to FAA management that the special conditions design of for the airplane system lithium-ion battery should include a requirement for a steel containment structure that would be vented overboard. FAA management overruled the specialist. The specialist worked to modify a new special condition that was applied to the battery installation so a containment system would be required. Unfortunately, FAA managers pushed to delegate 95 percent of the certification to the applicant, including the high risk,

new technology, battery installation. Without FAA safety engineer oversight, the ODA found the design without an enclosure to be compliant. Sadly, after certification, the airplane system lithium-ion battery experienced two extremely dangerous fire events and the FAA mandated the 787 fleet to be grounded (after the Japanese authorities grounded the Japan 787 fleet). The design changes the FAA mandated to allow the 787 to fly again included a steel battery containment box that was vented overboard; as originally proposed by the FAA aerospace engineer.

Issuing Exemptions that Are Not in the (Traveling) Public Interest

FAA management often issues exemptions with more consideration to the financial interest of the applicant compared with the safety interest of the Traveling Public. An example of this is a four-year time-limited exemption that allowed production of 737NG airplanes with a non-compliant Fuel Quantity Indicating System (FQIS), later extended to remove the time limit. Non-compliant means it does not meet the minimum engineering safety level. The non-compliance was with the fuel tank safety regulations that were issued in 2001. This regulation was created to prevent future accidents and address engineering design problems learned from the TWA Flight 800 accident, which was caused by a fuel tank explosion that the NTSB report states was most likely caused by a spark from the FQIS wiring inside the fuel tank. On December 18, 2013, the FAA issued a "Time-Limited Partial Grant of Exemption," Exemption No. 10905 (DMS docket FAA-2012-17). The justification stated by the applicant was the additional time needed to develop a compliant design. However, the applicant and all transport category manufacturers were aware of this design shortfall since 1998 because of the TWA 800 accident investigation[2]. This allowed continued production of a non-compliant design. It required incorporation of a few design changes but did not bring the design into compliance with the minimum level of safety required by the associated FARs. It granted the manufacturer 48 months to continue production of the 737NG, at the end of which the exemption required "the FQIS on all newly-produced airplanes must be shown to comply with §§ 25.901(c), Amendment 25-46, and 25.981(a)(3), Amendment 25- 102, or later amendments." Note that an applicant for new type design has only 60 months to complete the FAA type certification project.

[2]NTSB Safety Recommendation letter dated April 7, 1998, www.ntsb.gov/safety/safety-recs/RecLetters/A98_34_39.pdf

Near the end of the 48-month period, the manufacturer petitioned for an extension of the exemption (docket item FAA-2012-1137-0010). I was assigned the task to evaluate the petition for extension. I was also instructed to check with the FAA Counsel who had worked on the 2015 Boeing Settlement Agreement (https://www.faa.gov/news/press_releases/news_story.cfm?newsId=19875). I asked the FAA Counsel if the extension was related to the Settlement Agreement. He responded that yes, it is related to the Settlement Agreement. He recommended we not grant the extension and instead require the applicant comply with the requirements of the original time-limited partial grant of exemption. I drafted a denial letter and provided it to the manager. The manager ([redacted] then held the letter for several months until Boeing withdrew the petition for extension (FAA-2012-1137-0012). However, Boeing then submitted a new petition for extension and FAA granted them a permanent exemption (FAA-2012-1137-0019). This permanent exemption required some additional modifications to improve the safety of the 737NG FQIS, but it allowed Boeing to continue to produce 737NG airplanes with FQIS systems that did not meet the fuel tank ignition prevention requirements in the FARs issued because of the lessons learned in the TWA 800 accident investigation. This was more in the financial interest of the petitioner than the safety interest of the traveling public.

In contrast, the FAA issued an airworthiness directive in 1999 (AD 99–03–04) that required modification of the 737 Classic (737–100, –200, –300, –400, and –500 series ) FQIS to meet the same fuel tank ignition prevention requirements that they granted a permanent exemption for the 737NG. The FAA also issued an airworthiness directive in 1998 (AD 98–20–40) that required modification of the 747 Classic (747–100, –200, –300, SP, and SR series) FQIS that met the same fuel tank ignition prevention requirements. These airworthiness directives were issued because the FQIS failure mode that would have been eliminated by full compliance to the FARs for which the above exemption was granted was identified by the NTSB as the most likely ignition source that caused the TWA Flight 800 accident[3].

[3] "The National Transportation Safety Board determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system." (Executive Summary, NTSB Report on TWA Flight 800 Accident (NTSB/AAR-00/03)

FARs vs. Industry Consensus Standards

There is a move to replace the Federal Aviation Regulations for Transport Category Airplanes (14 CFR part 25) with industry developed "consensus standards." I caution against such a change. The FARs have been developed over time and new regulations typically were adopted to incorporate lessons learned from fatal accidents. Therefore, many of the FARs were issued to prevent future accidents based on those lessons learned. Replacing with industry standards may lose those lessons. Also, using industry standards, as was done with the FARs for Small Airplanes (14 CFR part 23) makes it difficult for the public to comment on changes or understand the regulations. FARs are public. Industry standards must be purchased from the industry organization.

Non-Compliant Design Features discovered during ODA Audits

When a design is type certificated using the ODA process, the ODA certifies to the FAA that the design compliant and the FAA then grants the type certification. Later, if the design is found not to be compliant during an audit, the issue is usually closed by a statement from the ODA that they will correct the non-compliance the next time they make a design change in that area; which could be never. I recommend that in cases where an ODA has said a design complies and it is later determined it does not comply, the ODA be required to bring the design into compliance during production. The production could continue under a time limited exemption until the compliant design is incorporated into production. The FAA could also evaluate the need to mandate retrofit of the airplanes delivered with the non-compliant design. Otherwise, the ODA company can produce the non-compliant design in potentially thousands of airplanes; each of which has a life of 20 to 30 years. This should be considered an unacceptable risk to the public, since the FARs do define the minimum acceptable level of safety for the type design.

Conclusion

I hope these examples demonstrate that even with the perceived limited resources of the FAA, their technical specialists do have the ability and resources to identify safety issues. Prior to the ODA system being implemented, FAA certificated the highly successful 757,767, 777, and 747-400 with fewer FAA engineers who conducted direct oversight of company designees. However, more recently the

FAA management safety culture often seems more interested in allowing applicants to produce designs that do not comply with the minimum safety standards defined by the FARs. This flawed FAA management safety culture has resulted in approval of airplanes with flaws resulting in grounding of the 787, two horrific 737 MAX accidents with the tragic loss of 346 lives and grounding the 737MAX for 20-months. Families have been destroyed. Airlines and the flying public have also been severely impacted by the groundings.

Balanced regulatory oversight supported by a strong FAA safety culture is not costly to the industry, it's the foundation on which the previous unprecedented safety record was built. Most of the aerospace engineers I worked with are dedicated public servants who want to do what is best for the traveling public. Not just what is best for applicant's short-term bottom line. The existing FAA management safety culture is broken and demoralizing to dedicated safety professionals.

I hope this committee considers this information when drafting future legislation.