Aviation Safety Whistleblower Report

U.S. Senate Committee on Commerce, Science, and Transportation

Chair Maria Cantwell
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Under the leadership of Chair Maria Cantwell, the Democratic staff of the Senate Committee on Commerce, Science, and Transportation is releasing this report as part of the Committee's continued investigation of the design and certification of the 737 MAX, and oversight of the Federal Aviation Administration's implementation of Congressionally-mandated safety reforms under the *Aircraft Certification, Safety, and Accountability Act*.

EXECUTIVE SUMMARY

On October 28, 2018, a brand new 737 MAX-8 aircraft certified less than two years prior by the U.S. Federal Aviation Administration (FAA), took off from Jakarta, Indonesia and within 13 minutes had plunged into the sea killing all 189 onboard Lion Air Flight 610. Just 133 days later, on March 10, 2019, another 737 MAX-8, Ethiopian Airlines Flight 302, crashed to the earth merely 6 minutes after takeoff from Addis Ababa, Ethiopia, leaving 157 dead.

These tragedies involving U.S.-manufactured aircraft followed a period in which the United States commercial aviation system experienced an unprecedented level of safety. According to the FAA, in the 20 years prior to 2018, commercial aviation fatalities decreased in the United States by 95 percent as measured by fatalities per 100 million passengers. In 2017 there were 4.1 billion passengers travelling by air internationally on scheduled commercial services. With a rate of 12.2 fatalities per billion passengers, this was the safest year ever on the record for global aviation. The 737 MAX crashes disrupted this trend line and called into question U.S. aviation safety oversight, presenting a historic challenge for U.S. policymakers.

In response, Congress passed the *Aircraft Certification, Safety, and Accountability Act*, which was enacted into law on December 27, 2020.[1] The Senate Committee on Commerce, Science, and Transportation ("the Committee") played a leading role in drafting this bipartisan legislation which made clear that a course correction on safety oversight was required in light of the 737 MAX tragedies.

This important safety reform legislation followed multiple, extensive investigations, including by the Committee, of the circumstances leading to and following two crashes involving the 737 MAX. The Committee's investigation and aviation safety work has been informed by whistleblowers—frontline officials from the Federal Aviation Administration ("FAA") and engineers from industry.

Whistleblowers perform a critical public service by exposing wrongdoing in the government and private sector. Here, seven individuals—all of whom have agreed to be identified in this report—contacted the Committee to convey their experiences and recommendations regarding the aircraft safety and certification environment at the FAA and within the industry. These seven individuals have a diverse range of experience in the U.S. aircraft certification ecosystem, with technical expertise from the FAA, engineering experience at Boeing and GE, and

other direct knowledge of aviation production, management, safety, and compliance processes.

The Committee staff interviewed these whistleblowers multiple times over the course of months, and they provided the Committee with their written statements and reports detailing their concerns. The Committee appreciates the whistleblowers' willingness to engage in this process and contribute to this report.

Some whistleblowers provided critical information and recommendations that shaped the Committee's approach to drafting aviation safety legislative reform passed into law in December 2020. These include: Dr. Martin Bickeboeller, a current Boeing senior engineer, Mike Dostert, a current FAA engineer, G. Michael Collins, a former FAA engineer, Curtis Ewbank, a former Boeing engineer, and Ed Pierson, a former Boeing senior manager.

The Committee sought to honor these whistleblowers by addressing many of their concerns when drafting the *Aircraft Certification, Safety, and Accountability Act*. The law took the important step of extending Federal whistleblower protections, similar to those that were available to Federal aviation safety workers and airline employees, to employees, contractors, and suppliers of aircraft manufacturers.

After the enactment of the safety reform law, other whistleblowers engaged with the Committee and provided instructive insight for oversight of the law's implementation, including Joe Jacobsen, a former FAA engineer, and Richard Kucera, a former GE Aviation engineer.

Whistleblowers like Mr. Kucera provided information indicating systemic problems continue to exist, including understaffed FAA offices charged with certification oversight responsibility for manufacturers and the continued risk of undue pressure under the FAA's system of delegated authority.

These whistleblowers also provided the Committee with their written statements and reports detailing their concerns. These individuals spoke with Committee staff multiple times to further educate staff on their claims. The Committee appreciates the whistleblowers' willingness to engage in this process and describe their experiences for this report.

Undue pressure on line engineers and production staff

FAA's certification process suffers from undue pressure on line engineers and production staff. This issue exists across different manufacturers and products.

According to whistleblowers, GE Aviation's GE9X engine program suffered from undue pressure on production staff acting on behalf of the FAA. For example, Mr. Kucera described being placed in an untenable position where he was responsible for conducting engine conformity tests on behalf of FAA, while also being charged with preparing GE engines to pass these same tests. This "would cross a line that should not be crossed," in his words. There were also scheduling pressures on production staff in the Boeing 787 program, which led to quality issues in the supply chain—problems that still persist. Boeing production staff experienced "relentless" schedule pressure in the 737 MAX program as well, raising safety concerns. Currently, the FAA office overseeing Boeing is investigating the continued problem of undue pressure under FAA's Organization Designation Authorization ("ODA") program.

Line engineers with technical expertise ignored

Line engineers with specific technical expertise were not listened to during the certification process for the 737 MAX and 787 programs. Whistleblowers described how warnings from specialized Boeing engineers were ignored. For example, Dr. Bickeboeller, a senior engineer at Boeing, stressed that his warnings of such supply chain non-compliances as part of the 787 project were still not adequately addressed by Boeing or the FAA. At the FAA, senior engineers who raised safety concerns were sidelined during the 737 MAX certification. According to Mr. Collins, an FAA aerospace engineer had reported to FAA management the risk of "catastrophic failure due to uncontrolled fire" posed by the absence of a fireproof enclosure on the 787 Dreamliner's lithium-ion battery. After the 787 was grounded by the FAA in response to fires started by the airplane system's lithium-ion battery, Mr. Collins reported "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."

Boeing oversight office in Seattle lacks enough safety engineers

FAA has failed to provide a sufficient number of safety engineers to the FAA office in Seattle overseeing the Boeing Organization Designation Authorization ("ODA"). The Boeing ODA is the largest and most complex in the United States. In February 2021, the Department of Transportation Office of Inspector General ("DOT OIG") findings showed the FAA office in Seattle has been chronically understaffed with only 25 engineers and technical project managers to oversee approximately 1,500 Boeing engineers who act on behalf of FAA. Under section 104 of the *Aircraft Certification, Safety, and Accountability Act*, Congress instructed FAA to examine and address any shortfall in the agency's technical

and engineering expertise to carry out its certification responsibilities, but FAA missed the statutory deadline of September 22, 2021 and continues to not complete the workforce review.

FAA certification processes do not require compliance with latest airworthiness standards

Whistleblowers point to gaps in the FAA certification process that have resulted in aircraft designs that do not meet the most recent airworthiness standards and less scrutiny of safety critical features. For instance, Mr. Ewbank cited gaps in the "Changed Product Rule" which allowed FAA to certify the 737 MAX according to dated airworthiness standards, like those for flight crew alerting systems. He asserts that flaws about the aircraft's older crew alerting system were "creatively hidden or outright withheld" from FAA during the certification process. The aircraft's unique flight control system ("MCAS") also did not receive proper scrutiny, part of a "slice and dice" approach Boeing took with the 737 MAX certification according to Mr. Ewbank.

FAA's strong oversight eroded under the ODA program

FAA's oversight of the certification process has eroded under the ODA program, the agency's latest system of delegated authority. Although by statute FAA retains responsibility for certifying that designs meet safety standards, the agency has, over time, increasingly delegated away its authority. The agency's system of delegation dates back a century, but recent efforts to utilize full organization-level delegation are new. In particular, under the ODA program FAA has embraced a "systems oversight" approach instead of directly supervising the engineering work of individual designees. In collaboration with industry, FAA has emphasized achieving efficiencies, through increased delegation, as a top priority. With this approach, FAA certified two transport category aircraft, the 787 and 737 MAX, which subsequently were been grounded because of safety issues at significant costs. For example, in addition to the loss of 346 lives and incredible pain for the victims' families, the 737 MAX crashes and grounding cost Boeing more than $20 billion and inflicted significant reputational harm to the U.S. aviation safety oversight system.

FAA and industry struggle with technical engineering capacity necessary for complex aircraft systems

FAA and industry are facing new challenges from complex aircraft systems involving human factors and automation. However, according to Mr. Ewbank, with the 737 MAX, FAA faced problems of technical capability and expertise to be able to certify complex aircraft systems. He observed that computer

technology and human-machine interfaces require a "significant amount of technical knowledge at the FAA." For the aviation manufacturing industry, companies face increased competition for engineering and technical expertise to further innovation in aircraft systems. While automated flight control systems can enhance safety, increased reliance on automation creates new safety challenges. These range from failure of pilots to correctly operate automated flight systems, to software malfunctions that generate faulty data, to the degradation of manual piloting skills.

Recommendations

During the Committee hearing titled "Implementation of Aviation Safety Reform" that took place on November 3, 2021, the Committee identified that the FAA has not fully implemented key provisions of the reform law and missed critical statutory deadlines. A theme throughout this report is that FCAA must take immediate action to implement outstanding items under the *Aircraft Certification, Safety, and Accountability Act*, which address key whistleblower concerns. Below is a list of key recommendations with a complete list found later in this report.

Strengthen FAA direct oversight of the ODA program

As required by section 107 of the *Aircraft Certification, Safety, and Accountability Act*, FAA should immediately strengthen direct supervision of the ODA delegation system, including starting January 1, 2020, FAA direct approval of individual ODA unit members—who are employed by industry but act on behalf of the FAA. FAA must also assign FAA safety advisors to enable direct supervision of and communication with ODA unit members, safeguards found under FAA's prior system of delegation with designated engineers. This reform was immediately effective with the law's enactment.

Take measures to address undue pressure at Boeing ODA

FAA should take immediate action to address undue pressure at the Boeing ODA with existing statutory authority. Ian Won, Acting Manager of the FAA Boeing Aviation Safety Oversight Office ("BASOO"), is investigating the Boeing ODA and instances of undue pressure. FAA should act upon any findings from this investigation.

An independent expert panel tasked by section 103 of the *Aircraft Certification, Safety, and Accountability Act* is reviewing the Boeing ODA's safety culture, undue pressure, and capability to perform FAA-delegated functions. FAA must

carefully review the panel's recommendations and report back to Congress on implementation, but the agency should not delay in taking action.

Ensure sufficient FAA technical and engineering capacity for safety oversight

FAA should complete a workforce review to determine gaps in staffing levels, as mandated by section 104 of the *Aircraft Certification, Safety, and Accountability Act*, and then properly staff the BASOO, which currently has an insufficient number of engineers and technical staff to oversee the Boeing ODA, the largest and most complex in the United States. The workforce review must account for new safety responsibilities required by the new law. FAA missed the workforce review deadline of September 22, 2021.

Limit delegation to industry until human factors assumptions are validated

FAA should immediately implement interim measures to effectuate section 106 of the *Aircraft Certification, Safety, and Accountability Act*, which prohibits FAA from delegating industry certification tasks related to safety critical design features until the FAA reviews and verifies all underlying human factors assumptions. This limitation on delegation was immediately effective upon the law's enactment.

Require that manufacturers adopt formal safety management systems with root cause analysis followed by corrective action

FAA must require, without delay, that aviation manufacturers implement safety management systems ("SMS"), an organization-wide approach to managing safety risk required by section 102 of the *Aircraft Certification, Safety, and Accountability Act*, and strengthen the agency's oversight over SMS programs to ensure, among other items, manufacturers are conducting root cause analysis. The law required that FAA initiate a rulemaking within 30 days of enactment. FAA has started the rulemaking process, but has not taken the substantive step of issuing a notice of proposed rulemaking.

Measure and improve FAA safety culture for frontline staff

FAA must conduct its annual safety culture assessment as required by section 132 of the *Aircraft Certification, Safety, and Accountability Act*. This survey will measure line employee's opinions on FAA safety culture and implementation of the voluntary safety reporting program mandated under the new law. According to Administrator Stephen Dickson's testimony to the Committee on November 3,

2021, FAA has not yet conducted the annual survey with the end of the calendar year approaching.

Mandate integrated aircraft safety analysis of designs

FAA should continue to update the “Changed Product Rule” in conjunction with international partners, as required by sections 115 and 117 of the *Aircraft Certification, Safety, and Accountability Act*, so that proposals for variants of existing aircraft designs (amended type certificates) have to undergo an integrated system safety analysis, taking in consideration the cumulative effects of proposed design changes to the aircraft, human factors issues, and impacts on training for pilots and maintenance personnel.

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I. FAA'S CERTIFICATION PROCESS SUFFERS FROM UNDUE PRESSURE ON LINE ENGINEERS AND PRODUCTION STAFF.

GE Aviation's GE9X engine program suffered from undue pressure on engineers acting on behalf of the FAA.

Richard Kucera, a former, longtime engineer with GE Aviation, led a division of GE's ODA unit responsible for supporting the issuance of production certifications or approvals for GE engines, on behalf of the FAA. Mr. Kucera claims that GE Aviation failed to meet its obligations under 14 C.F.R. § 183.57 to prevent interference or conflicting duties that affect the performance of authorized functions on behalf of the FAA. ODA unit member's FAA responsibilities may represent only a portion of an employee's duties.

As part of his FAA duties at the GE ODA, Mr. Kucera conducted conformity inspections to determine compliance with FAA standards. He also worked on the advanced GE9X engine developed by GE Aviation exclusively for the Boeing 777-X aircraft. As part of his ODA duties, Mr. Kucera identified 20-30 discrepancies with the GE9X engine which had to be resolved before the engine could be added to GE's production limitation record.[2] Subsequently, according to Mr. Kucera, GE Aviation threatened him with termination.[3] On April 1, 2021, Mr. Kucera sent an email to co-workers at GE Aviation, including his supervisor and his supervisor's superior, which stated in part:

> *[My supervisor] has, using authority granted to him by GE, threatened me, a fellow ODA administrator, with termination for having potentially jeopardized the schedule of GE's product certification (the GE9X) in the performance of my duties representing the FAA. That is, in my opinion, reckless, inappropriate, unproductive, and . . . unbecoming of the primary administrator of one of the FAA's preeminent ODA units*.[4]

Following the eventual certification of the GE9X engine, Mr. Kucera was put on a "coaching plan" by his supervisor, the GE ODA Lead Administrator acting as a company manager.[5] The coaching plan said: "[f]ailure to demonstrate sustained improvement in your performance will result in further actions to address your performance issues, including employment actions up to and including termination."[6] Mr. Kucera told the Committee that on March 19, 2021, a human

resources representative from GE Aviation "delivered the same termination threat verbally" and informed him of the coaching plan.[7]

In response to the coaching plan and the meeting with GE Aviation human resources representatives, on March 25, 2021 Mr. Kucera filed an "Integrity Concern" against his supervisor through GE's internal human resources system.[8] According to Mr. Kucera, he listed the following specific concerns:

> *That it was an improper use of his managerial authority to hold me, the person representing the FAA for making conformity determinations on the GE9X engine, responsible for the condition of the presented engine;*
>
> *That to similarly assign me responsibility for the conditions of engines and articles on the GE Catalyst engine would interfere with my ability to make conformity determinations impartially on the FAA's behalf; and*
>
> *That assigning to me the very burdensome task of "owning" the GE Catalyst TC conformity plan would constitute a failure – on his and GE's behalf – to "…ensure that no conflicting non-ODA Unit duties or other interference affects the performance of authorized functions by ODA Unit members."*[9]

On May 6, 2021, Mr. Kucera had a meeting with his supervisor and his supervisor's superior, further to his coaching plan.[10] According to Mr. Kucera:

> *After describing the very active role they envisioned for me to assure successful GE Catalyst FAA conformity inspections, I asked a pointed question, "Am I going to own the Catalyst TC Conformity Plan?" An uncomfortable silence followed, broken by [my supervisor], "Yes." Another uncomfortable period of silence followed, this time broken by [my supervisor's superior], "Do you have a problem with that?*"
>
> *I responded by explaining that it would be very unusual to make the person (me) who is responsible for determining conformity on the FAA's behalf simultaneously responsible for completion of the planned conformity inspections under a specified schedule*.[11]

Prepared by the applicant, a "TC Conformity Plan" specifies the FAA conformity inspections, which the FAA will conduct to provide confidence that 100%

conformance is being achieved by the applicant for each product, in this case the Catalyst turboprop engine. Mr. Kucera, in his role at the ODA, was responsible for overseeing and assuring the proper accomplishment of FAA conformity determinations in accordance with FAA regulations and guidance.

The coaching plan, which Mr. Kucera provided to the Committee, cites two "significant performance issues," which Mr. Kucera interpreted as GE Aviation asking him to be responsible for ensuring conformity of the GE9X engine while at the same time testing for conformity on behalf of the FAA.[12] The same coaching plan stated, in regard to the Catalyst turboprop engine: "[p]lan and execute a risk-based revision-controlled conformity plan with scorecard, to the current revision of the Catalyst Administered Certification Plan."[13]

In his letter to the Committee, Mr. Kucera characterized this language in the coaching plan as "holding me accountable for the condition of the GE9X engine that was presented for conformity inspection" and demanding "that I assume responsibility for conformity inspection results on GE's ongoing type certification project known as 'GE Catalyst,' a new turboprop engine," or else potentially be subject to termination.[14] Mr. Kucera saw GE as seeking to hold him responsible for the condition of the GE9X engine *presented to him* for review, and faulting him for the lack of communication within GE, as the applicant, *to him*, as the ODA unit member and FAA's proxy.[15] Similarly, he felt that GE sought to make him responsible, going forward, for the condition of the Catalyst engine that would eventually be presented *to him* for a conformity inspection.[16]

Mr. Kucera believes GE's actions and requests to be "diminishing the ability of GE ODA Unit members such as myself to act on the FAA's behalf inside the company" [17] and stated that forcing upon him "ownership" of FAA conformity inspections "would cross a line that should not be crossed."[18]

However, Mr. Kucera also reported how GE increased the workload of ODA unit members created thereby creating undue pressure. For example, GE Aviation had just one ODA unit member responsible for type certification conformity activities in its Prague, Czech Republic facility where the Catalyst engine was being developed.[19] According to Mr. Kucera, the sole ODA unit member in Prague was "overwhelmed by non-ODA unit duties" and not "given enough time to fulfill properly his ODA Unit duties."[20]

For Mr. Kucera, this was but one example of a broader trend at GE Aviation of "overuse of GE ODA Inspection Unit Members for non-ODA Unit duties, thereby making them unavailable for ODA Unit duties."[21] This could undermine his position leading a division of GE Aviation's ODA unit for production certificates:

Mr. Kucera said that he was denied authority to "override" the decision of an inspection unit member's manager "when that manager chose not to make them available for ODA Unit duties."[22]

Scheduling pressure on production staff in the Boeing 787 program led to quality issues in the supply chain.

According to Dr. Martin Bickeboeller, quality problems with the 787 supply chain are due to scheduling pressure and appear directly relevant to recent production issues with the aircraft.

As a Boeing employee since 1987, Dr. Bickeboeller has served in a high-level engineering role charged with setting technical direction for Boeing and resolving issues that arise when the company creates new products. He served as the Technical Fellow for Configuration Management compliance for 787 Dreamliner suppliers from 2008 to 2011.

Dr. Bickeboeller specifically expressed safety concerns about undue pressure on the production process in the 787 program and related quality problems in the supply chain.[23] It was part of his job, according to Dr. Bickeboeller, to stress the need for compliance oversight through all levels of the 787 Dreamliner's supply chain.[24]

Dr. Bickeboeller first identified internal supply chain management system failures for wing components used in the 787 in 2008 when he was the Technical Fellow for Configuration Management compliance for 787 suppliers.[25] With the 787, Boeing outsourced to suppliers an unprecedented amount of both engineering and production work, but still remained fully responsible for compliance and conformance of completed airplanes.[26]

Dr. Bickeboeller found that the 787 wing parts manufactured by Mitsubishi Heavy Industries specified on the Engineering Bill of Materials ("E-BOM") were not necessarily included on the Manufacturing Bill of Materials ("M-BOM") as well as on the actual wing, which was later confirmed by the FAA.[27] As a result, Dr. Bickeboeller filed internal complaints in 2009, expressing concerns about large end items such as the wing and fuselage sections manufactured by tiered suppliers such as Mitsubishi Heavy Industries (Japan), Global Aeronautica (now the Boeing factory in South Carolina) and Alenia Aermacchi (Italy) that were used in a number of initial build 787 aircraft.[28] These large end items did not comply with internal Boeing requirements and FAA requirements.[29] Dr. Bickeboeller's findings further support FAA's declaration in 2008 that Boeing had "several

systemic supplier control non-conformances requiring Boeing's attention prior to the FAA adding the 787 Model to Boeing's Production Certificate."[30]

Dr. Bickeboeller directly spoke to pressure within Boeing to meet production schedules:

> *During 2010-2011, it became clear, that in many instances Boeing management was more interested in a quick resolution without root cause corrective actions, leading to repeated violations of configuration management processes with impact on the product*.[31]

During the 787 project, Dr. Bickeboeller highlighted several open and pending Supplier Evaluation Records ("SERs") dealing with wing configuration issues.[32] These open SERs involved Alenia Aermacchi (now known as Leonardo) airplane sections and were highlighted by Boeing's Vice President for 787 Quality as a liability that could hinder the chances of a production certificate being issued for the 787.[33] After flagging his concerns with Boeing's quality control personnel, Dr. Bickeboeller was removed from the 787 program before the 787 received its FAA production certification in August 2011.[34]

Dr. Bickeboeller further spoke to this retaliatory action:

> *The removal from assignments occurred whenever there was a clash between schedule needs to deliver major components to Boeing's final assembly and the requirements to follow configuration management processes. Boeing intensified the removals when it became clear that the 787 production certificate extension was in danger due to finding more violations*.[35]

Among other retaliations, Dr. Bickeboeller was removed from his role as a senior technical specialist for the 787 program and was assessed poor job performance evaluations.[36] Dr. Bickeboeller noted that a more secure whistleblower reporting system at Boeing may have prevented the retaliation he faced for filing internal complaints about wing components manufactured by Mitsubishi and other tier one suppliers that violated Boeing and FAA standards.[37]

According to Dr. Bickeboeller, due to Boeing's inadequate oversight of its supply chain, noncompliant end items from various suppliers were shipped with incorrect Certificates of Conformity.[38] He explained that the FAA later investigated and substantiated a 2014 FAA whistleblower claim filed by Dr. Bickeboeller related to continuing Boeing supply chain issues with respect to Alenia Aermacchi end item non-compliances.[39] Dr. Bickeboeller's allegations related to configuration

management and supplier oversight were investigated and confirmed by the FAA, who issued a corrective action plan to Boeing to address the problems.[40]

During an interview with Committee staff in January 2020, Dr. Bickeboeller stressed that his warnings of such supply chain non-compliances as part of the 787 project were still not adequately addressed by Boeing or the FAA.[41] In October 2021, Dr. Bickeboeller maintained the following sentiments regarding Boeing:

> *The culture of regarding procedural violations as an issue to be dealt with when it is convenient is endemic at Boeing and within its executive management….If Boeing does not acknowledge their failures, how can they correct and improve their Corporate Compliance and internal Culture?!*[42]

Dr. Bickeboeller also submitted documentation to the Committee of a complaint he filed with FAA on October 25, 2021 to seek enforcement action against Boeing for repeat violations on supplier oversight from the 2008 FAA finding and corporate compliance issues.[43]

Specifically related to the 787 project, Dr. Bickeboeller outlined the following:

> *[The] 787 [project] had a culture of "making it happen." The tone of the program was captured best in the Ethics result regarding the MHI [Mitsubishi Heavy Industries] wings: "Boeing and Suppliers don't have to follow procedures until the production certificate is issued.*[44]

Dr. Bickeboeller described Boeing's safety culture flaws:

> *Boeing's culture of dealing with issues Boeing perceives [to be] "only a violation of regulations" but "probably not a direct product safety issue" is a dangerous culture not conducive to the proper safety of aerospace products.*[45]

The 787 supply chain and end item non-compliances highlighted by Dr. Bickeboeller beginning in 2008, prior to the 787's production certificate approval, are still relevant today. The actions of the same problematic Boeing suppliers including Mitsubishi Heavy Industries and Leonardo (formally Alenia Aermacchi), about which Dr. Bickeboeller filed formal complaints, are repeatedly producing defective wing components and other end items that are raising safety concerns and disrupting the overall 787 production line.[46,47]

Additional wing component defects – in the form of contaminated carbon fiber composites that could weaken composite bonding below allowed design limits – were produced by Mitsubishi Heavy Industries and recently identified as another manufacturing problem associated with the 787's wing.[48] According to internal FAA memos cited by *The Seattle Times*, Boeing reported this latest Mitsubishi produced defect to FAA in early 2021, but Boeing communicated to FAA last month that the composite contamination issue has been further identified at other major suppliers as well involving the 787's fuselage and tail.[49]

Leonardo, who has previously produced fuselage and other airplane sections which Dr. Bickeboeller highlighted as not conforming in accordance with FAA and Boeing compliance standards, was identified recently for manufacturing composite-related passenger and cargo door gap defects at the end of the 787 fuselage section.[50] Boeing paused assembly of these fuselage sections at their South Carolina factory to assess the problem.[51]

In addition, Leonardo applied an incorrect titanium alloy in certain fittings of fuselage sections it manufactured, which impacted fuselage frame and floor beam fittings (such as the critical floor-beam-to-fuselage-frame fittings) on more than 450 787 Dreamliners.[52] Since the FAA assessed this defect as having the potential to produce unsafe conditions if two or more adjacent fittings included the wrong titanium alloy, two aircraft with such defects were identified and grounded until the defect could be fixed.[53] Much like Dr. Bickeboeller's concerns about the supplier's components, FAA's assessment in their recent memo notably included that "Leonardo relies on mechanics to inspect their own work when they assemble the structures, with limited or no oversight by quality inspectors."[54]

Due to continued manufacturing defects and overall production issues, 787 Dreamliner deliveries are still halted as of the date of this report. Boeing stated in late October 2021 that it had reduced its 787 production rate down to two per month to solve production issues, a reduction from their previously planned production rate of five aircraft per month.[55] Boeing's proposal for 787 production inspections is being evaluated by the FAA for the appropriate levels of inspections needed to resume Boeing 787 deliveries.[56]

Boeing production staff experienced "relentless" schedule pressure in the 737 MAX program.

Ed Pierson claims pressure on line staff in the 737 MAX program created safety issues. Mr. Pierson worked for Boeing, including as a senior manager, for 10

years, retiring in 2018. He oversaw production support for the final assembly of the 737 series, wing components, and the U.S. Navy's P-8 Poseidon aircraft, among other responsibilities.

Mr. Pierson described to the Committee quality control problems and business pressures at Boeing's production facility in Renton, Washington, where the 737 MAX was manufactured.[57] He stated: "[t]he conditions within the production environment could easily have led to mistakes that affected the airplanes' critical electrical system, among other possibilities."[58] According to Mr. Pierson, the Renton facility was under "relentless schedule pressure"; coupled with "a huge rolling logjam of unfinished airplanes," "a shortage of skilled union employees (electricians, mechanics, technicians & quality inspectors)"; "an unusually high number of quality defects and functional test failures"; "an overworked workforce"; and "an increase in high hazard worker safety near misses."[59]

Mr. Pierson also observed that, in addition to the Lion Air and Ethiopian Airlines 737 MAX accidents:

> *there were at least 13 other reported safety incidents involving new 737 MAX airplanes . . . that were all manufactured at the 737 factory in Renton, Washington during the same period of time. . . . Most shocking of all, 11 of these 13 safety incidents occurred in the five months between the Lion Air crash and the Ethiopian Airlines crash. Thus 2 safety incidents per month. So at a time when Boeing and the FAA should have been operating at an extremely heightened sense of awareness after the Lion Air crash, the MAX continued to average two safety incidents per month for the five months leading up to the Ethiopian Airlines crash. At this rate, if the MAX had not been grounded in March 2019, there could have been another 42 safety incidents involving airplane systems (other than MCAS) by December 2020—which means a correspondingly higher probability of another fatal accident.*[60]

The FAA office overseeing Boeing found that undue pressure continues to exist under the FAA's ODA program.

The FAA's Boeing Aviation Safety Oversight Office ("BASOO") is conducting an investigation of undue pressure at the Boeing ODA. The BASOO provides oversight of delegated authority granted to Boeing by FAA.

According to an August 19, 2021 letter from Ian Won, Acting Manager of the BASOO, FAA informed Boeing that its ODA as a whole was being investigated to

assess the level of independence of ODA engineering unit members ("E-UMs") and project administrators, and its ability to transparently share information with FAA without fear of retaliation.[61]

The investigation, conducted by the BASOO Management Team, assessed the level of the ODA's independence from May 2021 through July 2021.[62] Based on FAA's survey, 35 percent of respondents at Boeing's ODA voiced concerns of undue influence.[63] Consistent with ongoing concerns of whistleblowers who have been in contact with the Committee, FAA found that Boeing's "company culture appears to hamper members of the ODA unit from communicating openly with the FAA."[64]

Under Title 14 CFR § 183.57(c), "Responsibilities of the ODA Holder," an ODA Holder must "ensure that no conflicting non-ODA Unit duties or other inference affects the performance of authorized functions by ODA Unit members." By contrast, FAA's BASOO Office found Boeing's organization structure to have a strong influence on the appointment, management, and performance of ODA unit members and administrators, "which provides ample opportunity for interference rather than independence."[65]

FAA interviewed 32 Boeing staff members during its investigation.[66] The BASOO's recent investigation found some of Boeing's ODA engineering unit members have had a "bad experience with schedule pressures from the ranks of engineering."[67] Another respondent described how ODA interference occurs in favor of the industry applicant in order to keep production deliveries on schedule:

> *The applicant leverages poor process allowances to extend delivery during "suspected" non-conformances that may arise. To me either there is a non-conformance or not, but the applicant creates uncertainty allowed in the process purposefully to support delivery schedule…"*[68]

Another respondent explained the safety and airworthiness ("SAW") organization as an advocate for the industry applicant:

> *I am called into SAW meetings and they bring in an SME [Subject Matter Expert] from the program and say my position is flawed for some reason and that I can go ahead and make the finding without FAA involvement. This is something I have to stand up to often*.[69]

A different respondent similarly agreed, stating:

> *SAW should not be in the chain of command of E-UMs [engineering unit members] performing as finders of compliance or agreeing for showing of compliance or in BPSM [Boeing Problem Solving Model] development or COS [Continued Operational Safety] etc. They should only go through the ODA and not SAW, which puts direct conflict in the process*.[70]

FAA determined these concerns warranted an objective review and additional fact-finding and voiced its intent to conduct a subsequent anonymous and independent survey at a future date of all 1,400 Boeing unit members to identify remaining concerns.[71] FAA detailed its desire to refer survey results to Boeing's safety management system for risk management mitigation and assessment and to work with Boeing on developing corrective action measures to address ODA unit member and administrator concerns.[72]

Notable aviation safety bodies have recognized the need for such ODA reform. The Joint Aviation Technical Review ("JATR") recommended that FAA ensure Boeing ODA engineering unit members are "working without any undue pressure when they are making decisions on behalf of the FAA" and "have open lines of communication to FAA certification engineers without fear of punitive action or process violation."[73] These recommendations are key parts of JATR's broader observations of FAA's delegation of certification authority to Boeing that stress FAA should review Boeing's ODA work environment and ODA manual as a whole.

II. LINE ENGINEERS WITH SPECIFIC TECHNICAL EXPERTISE WERE NOT BEING LISTENED TO DURING THE CERTIFICATION PROCESS.

Early warnings from Boeing engineers in the 737 MAX and 787 programs were ignored.

Curtis Ewbank is a former Boeing aerospace engineer specializing in integrating flight deck system design with flight crew operations. Mr. Ewbank worked on the Flight Deck Crew Operations and Integration team at Boeing, where he was "responsible for reviewing flight control system design, designing appropriate crew alerting and crew procedures based on expected failures, necessary crew action, and overall Boeing flight deck philosophy."[74] He also worked with the Aviation Safety team to analyze loss of control accidents and flight deck design features relating to the 737 series that "would work to break the accident chain of various events."[75] Mr. Ewbank raised concerns to Boeing management in early 737 MAX discussions with the FAA and during his time working on the 737 MAX program.[76]

Mr. Ewbank submitted an ethics statement to the Committee that he had previously sent to internal Boeing investigators in 2019.[77] In the statement, Mr. Ewbank details the actions of Boeing management and why he felt it should be investigated for "ethical lapses."[78] Mr. Ewbank began drafting this statement after the Lion Air Flight 610 accident in October 2018, based on his recollections of potentially significant events from the design process of the 737 MAX, in order to assist the company in examining structural organizational deficiencies that may have contributed to the accident. Mr. Ewbank also viewed the statement as a means to discuss such concerns with his management. Following the Ethiopian Airlines Flight 302 crash and his disappointment with the comments of Boeing management, Mr. Ewbank submitted his ethics statement to Boeing on April 29, 2019.

Through his involvement in discussions related to Maneuvering Augmentation Characteristics System ("MCAS") and reliable air data measurements related to the 737 MAX, Mr. Ewbank developed serious concerns about error detection and data integrity of the 737 MAX air data system that included the angle-of-attack sensor.[79] He noted that the Boeing Commercial Airplanes ("BCA") "Strategy for Reducing the Risk of Loss of Control Events" determined aircraft energy state awareness as a major variable in flight accidents where the crew loses control of the aircraft.[80]

Through his work as a flight crew operations integration engineer that was closely aligned with work performed by Boeing's Aviation Safety Department, Mr. Ewbank became familiar with the Commercial Aviation Safety Team ("CAST") industry panel, which is charged with developing data driven strategies to reduce the risk of commercial aircraft fatalities.[81] Mr. Ewbank cited that CAST identified six out of 18 loss of control incidents that involved Boeing 737 aircraft, with five incidents classified as fatal accidents.[82] Additionally, he stressed that CAST's Airplane State Awareness Joint Safety Analysis Team ("ASA JSAT")[83] highlighted invalid source data from components, such as air data system sensors or probes and angle of attack ("AOA") vanes or sensors, as causational factors in five out of 18 flight accidents involving loss of control of the aircraft.[84]

Mr. Ewbank felt that the reliance on one AOA input as part of MCAS on the 737 MAX[85] was a serious design flaw.[86] Since Boeing risk mitigation strategy recognizes aircraft energy state awareness as a contributing factor to loss of control flight accidents, Mr. Ewbank strongly asserted that Boeing management was well aware of the AOA data reliability and validity sensor design flaw and how to address it:

> *When CEO Dennis Muilenburg states that there was no "technical slip or gap" in Boeing's design of the 737 MAX, where a single AOA sensor drove MCAS, he makes a false statement; Boeing, the FAA, and a broad industry team were aware of the necessity of detecting invalid source data and preventing its use by downstream systems. The failure to do that in MCAS is unconscionable, and presenting this situation as anything other than a failure is unethical.*[87]

Notably, Mr. Ewbank and representatives from Boeing's Aviation Safety Department highlighted a recommendation to Boeing management, as included in the Boeing Strategy for Reducing the Risk of Loss of Control Events, to implement an "Enhanced Bank Angle Warning" on both the 737 NG and 737 MAX models.[88] Per his description, the feature was developed and assessed in response to "a trend of 737 accidents with a loss of spatial awareness in the roll axis."[89] The recommendation to implement this warning was supported by a study involving 30 line pilots in the Boeing engineering simulator that indicated the feature:

> *…would have a positive effect on spatial awareness for the pilot flying and a reinforcing effect for the pilot not flying to take over if the other pilot was not recovering appropriately" during a flight safety incident.*[90]

Mr. Ewbank pointed out the warning was designed around the same time as MCAS and "includes a validity check on its inputs" to ensure that an error in a single sensor cannot falsely activate the alert.[91] However, Mr. Ewbank spoke to difficulties with implementing the warning in 737 NG aircraft that were being produced and getting approval to incorporate it into the 737 MAX – noting it "affected upset recovery training at a time when every training impact could affect the profitability of a major program" at Boeing.[92] In Mr. Ewbank's view, this underscores the fact that program concerns of cost and training were a higher priority than improving aviation safety through data-driven design of appropriate interventions.[93]

According to Mr. Ewbank, "the implementation of synthetic airspeed on the 737 MAX was recommended as a trade study several times."[94] On the 737 series, Mr. Ewbank explained that if the display of air data on one side of the flight deck is "found to be erroneous," such "information cannot be replaced with information from the other side," which leaves the pilot with bad information until the problem clears on its own, unlike on other Boeing models.[95] Mr. Ewbank relayed his manager's thoughts regarding synthetic airspeed implementation on the 737 MAX and his own concerns that this opinion was contrary to safety recommendations of many Boeing engineers and technical specialists:

> *Notably, my current manager stated to me that synthetic airspeed wasn't on the MAX because it 'doesn't give the flight crew what they need.' That statement is a serious misunderstanding of the work that went into the development of synthetic airspeed and the collaboration of pilots, Crew Operations Engineers, Systems Engineers, and Aviation Safety analysts that supported such action. This misunderstanding and the processes that led up to its dissemination to the management team are a serious ethical and safety issue.*[96]

According to Mr. Ewbank, the air data integrity monitors associated with synthetic airspeed were intended to improve the flight deck environment in scenarios where crew alerts activate in response to erroneous air data, based on analysis of previous fatal accidents with erroneous air data as an underlying cause.[97] Mr. Ewbank as well as other Boeing engineers and technical specialists, recommended the incorporation of synthetic airspeed components on the 737 MAX to ensure accurate displays of reliable air data.[98] Mr. Ewbank explained that the absence of the ability to silence an erroneous overspeed aural on the Boeing 737 was identified as a causational factor of the 1996 Birgenair Flight 301 accident.[99] Leading up to this particular incident, crash investigations determined

the flight crew was confused by "erroneous indications of relative speed increase and an overspeed warning" before the stick shaker warning activated.[100] Notably, Mr. Ewbank highlighted a similar occurrence with crash investigation data from the Ethiopian Flight 302 accident:

> *The fact that the overspeed aural was continuously annunciating during the final minutes of Ethiopian 302 calls to question whether not implementing an NTSB/FAA recommendation for cost reasons (decades ago) was appropriate. Additionally, synthetic airspeed was recommended on the 737 to prevent erroneous air data information getting to the stall warning speed floor mode; a feature only the 737 has that will annunciate the stall warning for low airspeed and not just angle of attack.*[101]

Despite this feature not being implemented on the 737 MAX in advance of the Lion Air and Ethiopian Air crashes, Mr. Ewbank noted that synthetic airspeed *was* implemented on the Boeing 787 "as a byproduct of the need for flight controls to have highly reliable angle of attack data."[102] The development of the 787 is in contrast to the 737 MAX, where a new flight control function that heavily depended on AOA data was implemented with single-threaded, potentially unreliable AOA data. Per Mr. Ewbank, Boeing's knowledge and experience from prior design efforts should have prevented this situation from arising:

> *The monitors that make synthetic airspeed possible monitor and detect erroneous angle of attack data, and then work to prevent the use of erroneous data by downstream systems. This basic design philosophy established by flight controls makes it clear that piping a single sensor output to a control law without a data check is simply not an acceptable design – even without synthetic airspeed.*[103]

Mr. Ewbank described to the Committee an instance where Boeing withheld information concerning 737 autothrottle problems from foreign regulators while the 737 MAX was undergoing initial certification.[104] Specifically, Boeing received a request from the European Union Aviation Safety Agency ("EASA") citing five events when a "737 experienced an autothrottle disconnect on approach and the flight crew did not respond appropriately," and asked if Boeing was aware of any further events to inform EASA's evaluation of the 737 MAX design.[105]

Mr. Ewbank noted that these events were related to items under FAA's Continued Operational Safety Program ("COSP") involving aircraft that had a speed deviation alert installed, which Mr. Ewbank noted as having the "same

caution/warning light as the autothrottle disconnect," creating flight crew confusion.[106]

In 2014, Boeing tasked Mr. Ewbank and his human factors specialist colleague with reviewing Boeing's databases of "in-service" events to determine if there were any potentially relevant incidents.[107] They identified "5 events that may have had the same root cause as the COSP items" and communicated this to management.[108] At the time that EASA made their inquiry to Boeing, Mr. Ewbank recalled the following:

> *No changes were planned for this issue on the MAX; a design where the autothrottle disconnect alert is already non-compliant with regulations (FAR 25.1329(k) requires a Caution – an amber light and an aural – the 737 just has a red flashing light).*[109]

Additionally, Mr. Ewbank described Boeing's actions regarding EASA's request:

> *Following a discussion with my manager and second-level manager…the decision was made to not tell EASA about these events, as they had not come through the COSP process, and that we would fix the issue ourselves.*[110]

Mr. Ewbank interpreted Boeing's response as the company withholding information about known incidents.[111] He concluded as follows:

> *While this may not be completely unethical, it is presented here to build a picture of Boeing management's attitude towards regulatory bodies – even if the company is internally aware of an issue, this is not information it will share with the regulator, especially if it is dancing around a system that is not already in compliance and does not want to bring that to their attention. This dance has a negative effect on the safety culture at Boeing.*[112]

Mr. Ewbank described how management decisions impacted him as an engineer working to implement design changes at Boeing during the development of the 737 MAX:

> *I left my job at the Boeing Company in 2015 in protest of management actions to rationalize the poor design of the 737 MAX. . . . Prior to my departure in 2015, my manager argued against the design changes I wanted to make by stating, "People have to die before Boeing will change things." The time for change is now.*[113]

In response to incidents he witnessed that contributed to the degradation of Boeing's safety culture and heightened risk of related aviation safety problems, Mr. Ewbank recommended the creation of a whistleblower system at Boeing where ethical concerns about designs can be evaluated independently of Boeing by an expert review panel rather than by "internal counsel seeking to protect the company from liability."[114]

FAA senior engineers who raised safety concerns were sidelined during the 737 MAX certification.

Michael Collins, a former FAA engineer, shared examples of FAA management agreeing with the positions of aircraft manufacturers, over the concerns of FAA technical specialists and engineers.[115] Mr. Collins worked at the FAA for over 29 years specializing in aircraft propulsion.

Mr. Collins pointed to FAA ignoring the concerns raised by at least 13 FAA aerospace engineers, one pilot, and four FAA managers regarding the method of compliance FAA used to evaluate the 737 MAX's rudder control design.[116] He also highlighted a safety-critical problem with a fuel pump on the 737 MAX—the pump had an electrical circuit protection problem—which FAA certified over the recommendation of an FAA engineer.[117]

In another example, Mr. Collins pointed to FAA's management and delegation practices regarding the certification of the faulty lithium-ion battery on the 787 Dreamliner as part of a "flawed FAA management safety culture."[118] Mr. Collins described how FAA managers pushed to delegate 95 percent of the 787 Dreamliner's certification to Boeing.[119] This delegation decision included the certification of new high-risk battery installation technology, a decision made against the recommendation of a technical specialist who identified the system's safety critical design flaw.[120] In the absence of FAA technical and safety engineer oversight, Boeing's ODA found the lithium battery system design to be compliant.[121] Later on, *this exact design flaw led to dangerous 787 fire incidents and the eventual FAA grounding of the 787 Dreamliner*.[122]

According to Mr. Collins, an FAA technical specialist had reported to FAA management the risk of "catastrophic failure due to uncontrolled fire" posed by the absence of a fireproof enclosure on the 787 Dreamliner's lithium-ion battery.[123] To minimize this safety-critical flaw, the technical specialist proposed to FAA management a design change that would have required a steel containment structure for the battery with overboard ventilation, but according to Mr. Collins: "FAA management overruled the specialist."[124] After the FAA

grounded the 787 in response to fires started by the airplane system's lithium-ion battery, Mr. Collins reported "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."[125]

Mr. Collins, who began working at the FAA in 1989, illustrated a safety oversight environment in place at FAA earlier in his career, and prior to the ODA system, that was much different than the one he worked in leading up to his retirement in July 2018:

> *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 that the FARs defined the minimum level of safety for airplane designs….It was a much more collaborative environment from 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*.[126]

Mr. Collins noted a decline in safety culture ever since the FAA's Fuel Tank Safety rule (aimed to increase protection against fuel tank ignition sources) was passed in 2001[127] in response to the Trans World Airlines flight 800 accident.[128] Mr. Collins praised the earlier Designated Engineering Representatives ("DER") system in place at this time as an example of a consensus-driven and collaborative safety culture from which the FAA had subsequently deviated.[129]

Mr. Collins spoke about how, under the previous DER system, FAA and industry worked together to address noncompliant aircraft designs to ensure they met minimum levels of safety set by the Federal Aviation Regulations ("FARs").[130] Under the DER framework, if Mr. Collins and his FAA colleagues discovered a design was not compliant with FAA regulations, they identified the issue to their managers and the aircraft manufacturer's DER.[131] Mr. Collins shared, "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 standards defined in the FARs."[132] Additionally, Mr. Collins added:

> *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.*[133]

Mr. Joe Jacobsen is another former FAA safety and aerospace engineer who retired in March 2021. Before joining the FAA, he spent 11 years at Boeing as an aerodynamicist on the 767 and 777 programs.

According to Mr. Jacobsen, at FAA "managers are actively excluding the most senior engineers when they consider them an obstacle to quick resolution of difficult issues."[134] Mr. Jacobsen took particular issue with FAA's certification of the Angle of Attack ("AOA") input on the 737 MAX.

According to Mr. Jacobsen, among the FAA senior engineers with experience working on flight control issues at Boeing—including Mr. Jacobsen (who described himself as one of the most experienced technical specialists in aircraft performance and handling)—none were involved in directly supervising the Boeing ODA to work on the AOA design fix in the aftermath of the Lion Air Flight 610 crash.[135] Instead, Mr. Jacobsen said that this authority was left to a small number of engineers based out of the Boeing Aviation Safety Oversight Office ("BASOO").[136] He also related that, in the end, *the same ODA unit members that erroneously certified the AOA design flaw were again assigned to evaluate the operational mitigations and AOA design fix after the Lion Air Flight 610 crash.*[137]

Mr. Jacobsen described the FAA holding a meeting in the aftermath of the 737 MAX grounding "to discuss an internal FAA report stating that the original certification was done properly."[138] At this meeting, Mr. Jacobsen voiced his opinion that "the original certification was done improperly."[139] Based on these events, Mr. Jacobsen viewed FAA management as being keen to keep the 737 MAX redesign within Boeing's control.[140]

> *I was shocked to discover that the airplane was purposely designed and certified to use just one AOA input for a critical flight control function. Within the next couple of days, I was in the office and I spoke to three different managers with direct responsibility for this topic within the FAA. I told them that the use of one AOA input was a serious design flaw.*[141]

It is Mr. Jacobsen's view that he and his fellow senior engineers would have identified MCAS as a serious design flaw:

> *Direct FAA scrutiny of the design (failure aspects) was missing. If FAA engineers were briefed on the design, I'm confident that 6 to 8 (my estimate, as noted previously) of our experienced engineers would have identified the design flaw.*[142]

Another whistleblower, a current FAA engineer, Michael Dostert, reported to the Committee that "[s]afety engineers in the Aircraft Certification Service ("AIR") have serious concerns about the weakened FAA safety culture and political climate that is putting self-interest ahead of safety."[143] In his July 7, 2020 letter to the Committee, Mr. Dostert explained:

> *FAA managers are selected and rewarded based upon a demonstrated willingness to promote industry positions. . . . According to a reliable source, SES bonuses include incentives based upon meeting industry schedules and needs. Promotions and awards are routinely provided to managers who demonstrate support of applicants over safety engineers and compliance*.[144]

Line staff at FAA are concerned that external pressures from industry manufacturers are undermining safety.

In August 2020, the FAA released the results of a safety culture survey,[145] conducted in late 2019 and in focus groups in early 2020 that found that rank-and-file FAA staff were concerned that external pressures from industry manufacturers were undermining safety:

- 49% percent of the FAA employees responding indicated they believe that safety concerns or incidents will not be addressed;
- 43% of employees believe the FAA delegates too many certification activities to industry; and
- 34% percent of employees said that the "fear of retribution" is one reason employees don't report safety issues.[146]

FAA employees in the field reported feeling strongly pressured by industry to meet production deadlines and believing that industry will bypass "problematic" front-line staff who are perceived as "getting in the way," instead going directly to FAA leadership.[147] In other words, they felt industry manufacturers—not line engineers—are in charge and dictate the process. In describing problems with FAA management, one FAA employee said: "[t]hey [industry] just keep going up the chain until they get the answers they want."[148] Such pressures prevent FAA frontline workers from reporting safety issues out of fear of retaliatory action.

For 2021, the FAA has yet to complete the annual safety assessment mandated by the *Aircraft Certification, Safety, and Accountability Act* to evaluate FAA's Office of Aviation Safety, FAA safety culture, and implementation of any voluntary safety reporting program. The safety assessment is required to be completed by the end of the calendar year.

III. FAA HAS FAILED TO PROVIDE A SUFFICIENT NUMBER OF SAFETY ENGINEERS TO OVERSEE BOEING.

The FAA office overseeing the Boeing ODA, the largest and most complex in the United States, is chronically understaffed.

The Boeing Aviation Safety Oversight Office ("BASOO") provides oversight of authorized functions granted to the Boeing ODA, the largest in the United States.[149] The Boeing ODA unit includes approximately 1,500 Boeing-designated ODA representatives or unit members.[150] In addition to its size, the Boeing ODA is arguably the most complex ODA organization in the country. For example, in 2019 the Boeing ODA had five times as many major certification projects as the next largest ODA.[151]

FAA formed the BASOO in 2009, the same year that FAA and Boeing transitioned to the ODA delegation system. "The BASOO is responsible for overseeing the Boeing ODA and certification of Boeing products, while the Seattle Aircraft Certification Office ("SACO") is responsible for overseeing continued operational safety management of Boeing products once they are certificated."[152] Prior to the formation of the BASOO, the SACO was responsible for overseeing certification as well.[153] According to an FAA PowerPoint produced in 2010, ostensibly the BASOO was created to "increase focus on delegation; promote integration and standardization; and facilitate functional alignment based upon . . . FAA safety priorities."[154]

Mr. Dostert, a current aerospace engineer at the FAA, reported to the Committee as follows:

> *The FAA safety culture within Aircraft Certification resulted in the creation of an organizational structure with less than 45 employees doing oversight of Boeing. This organization, the Boeing Aviation Safety Oversight Office (BASOO) was implemented intentionally by FAA managers to remove the FAA safety engineers in the Seattle Airplane Certification Office (SACO) from the "Critical Path" of certification. Current head of Aviation Safety, Ali Bahrami, viewed engineers in the SACO as overly conservative and he also wanted to make sure Boeing got expedited service. The FAA has over 44,000 employees, yet the FAA management set up an organizational structure that did not have enough resources to have*

> *safety engineers evaluate the assumptions and type design of a brand new flight control feature on an airplane model that would carry the majority of the US travelling public for the next 30 years.*[155]

More specifically:

> *The organizational structure when the BASOO was created resulted in inherent under staffing and lack of experienced safety engineers. Prior to the BASOO, the SACO had a staff of many flight controls specialists including senior engineers and a manager with flight controls background. The SACO staff had significant resources and expertise to do oversight of Boeing. Conversely, the BASOO had only 2 flight controls specialists for all Boeing programs and both had very limited experience. Both were low paid government pay scale "I band" engineers. Neither had flight controls, or even 737 systems experience/training.*
>
> *Currently there are 4 managers and over 40 authorized positions in the BASOO. . . . Prior to the ODA, all certification oversight was done by the Seattle Aircraft Certification Office.*[156]

According to a February 2021 DOT OIG report detailing weaknesses in FAA's certification and delegation processes, as of February the BASOO had 47 FAA employees, with only 25 engineers and technical project managers.[157] Of the 24 FAA office managers and personnel at the BASOO interviewed by DOT OIG, 15 "expressed concerns with the current levels of staffing resources" and spoke to high levels of staff turnover.[158] According to the report, the BASOO did not have a dedicated human factors specialist to provide technical expertise at the time of the 737 MAX certification, and instead relied on pilots and flight test engineers.[159]

On October 25, 2021, the FAA reported to the Committee that the BASOO has 53 FAA employees, with 31 engineers and technical project managers. This is a small increase from October 2019 when the Joint Aviation Technical Review (JATR) found there were only 18 working-level engineers and 6 senior engineers (24 engineers total) at the BASOO.[160]

The JATR also concluded there may be a lack of capacity and depth of experience of BASOO engineering members to approve and make findings of compliance for retained items.[161]

"The BASOO is required to perform a certification function, including making findings of compliance of retained (non-delegated) requirements, while also performing the oversight function of the Boeing ODA. The BASOO must have the resources to carry out these two primary functions without compromise."

- *Joint Aviation Technical Review*

The 2019 JATR report described how FAA's resource shortfalls at the BASOO (and other allocated resources) may have contributed to an inadequate number of FAA specialists being involved in the 737 MAX certification program.[162] In some cases, BASOO engineers had limited experience and knowledge of key technical aspects of the 737 MAX program. JATR found that FAA has "very few human factors and human system integration experts on its certification staff."[163] At the same time, JATR noted "issues in human-machine interaction are at the core of all recent aviation accidents and are implicated in the two 737 MAX accidents."[164]

Similarly, DOT OIG's February 2021 report found that the BASOO did not have a dedicated human factors specialist to provide technical expertise at the time of the 737 MAX certification, and instead relied on pilots and flight test engineers.[165] According to DOT OIG interviews with managers and personnel, the BASOO suffers from high rates of turnover and the office has "lost valuable institutional knowledge" as a result.[166] FAA BASOO staff cited a lack of sufficient staffing in positions such as software engineers and systems analysis and human factors specialists, which DOT OIG identified as impacting FAA's ability to "robustly review submitted safety assessments, such as examinations of assumptions made and failure mode testing by Boeing."[167]

IV. FAA CERTIFICATION PROCESSES HAVE RESULTED IN AIRCRAFT DESIGNS THAT DO NOT MEET THE MOST RECENT AIRWORTHINESS STANDARDS.

FAA's aircraft certification process allowed critical safety features with the 737 MAX to avoid scrutiny.

Mr. Ewbank, a former Boeing engineer, specifically noted that Boeing took the position that, under the Changed Product Rule (14 CFR § 21.101 and 14 CFR § 21.19), the company did not have to conduct extensive evaluations of flight decks systems for potential crew error as normally required under 14 C.F.R. § 25.1302—instead, merely an analysis of changed systems.[168] Mr. Ewbank stated that "this certification tactic severely limited the range of human factors evaluation of the 737 MAX systems."[169] In addition, Mr. Ewbank spoke in depth to "the drive by [Boeing] management to update the 737 MAX in a piecemeal fashion, keeping certification and training costs low" that went against Boeing's engineering workforce's "ethical imperative to protect the safety of the public."[170] According to him, if the MAX had been certified to a full set of FAA regulations, it would have been a safer airplane by entering service with the most up-to-date understanding of system design, with updated critical human factors recommendations to respond to more technologically advanced automation processes.[171]

With respect to the need to evaluate the Maneuvering Characteristics Augmentation System ("MCAS") for changes that could result in potential crew error, Mr. Ewbank said "there were many places where those system interactions should have been analyzed but were not due to the means of compliance granted to Boeing for its amended type certificate."[172] He remarked the "MCAS design was a victim of this 'slice and dice' approach; crew interfaces for Air Data were unchanged and Autoflight only had minor changes."[173]

Mr. Ewbank cautioned the following:

> *This lack of analysis reduces the overall safety of the 737 MAX as compared to a newly developed airframe. And this use of the changed product rule to avoid scrutiny on unchanged systems is enormously important to the future of aviation safety – the changed/unchanged system line on the 777X is even more*

> *convoluted and involves more complicated systems than the 737 MAX.*[174]

Mr. Ewbank believes that Boeing concealed from FAA flaws about the older crew alerting system in the MAX: awareness of these flaws "was creatively hidden or outright withheld from regulators during the certification process."[175]

Going forward, Mr. Ewbank recommended the FAA create the means to evaluate aircraft development models for regulatory compliance and require Boeing to submit them at multiple stages of the design process to prevent compliance information from being hidden from the FAA.[176]

Mr. Jacobsen, a former FAA engineer, also described how the FAA certification process allowed applicants to avoid scrutiny of safety-critical items. He laid out safety-critical concerns and design non-compliances with the 737 MAX's MCAS and autothrottle system, systems identified as contributing to the crashes of Lion Air flight 610 and Ethiopian Airlines flight 302.[177]

> *I was shocked to discover that the airplane was purposely designed and certified to use just one [Angle of Attack ("AOA")] input for a flight critical function… we have a long history of AOA sensor failures, for a multitude of reasons, and that the regulations wouldn't allow a critical function such as the rapid movement of the horizontal stabilizer using one unreliable input. I'm not the only engineer who would have identified this design flaw.*[178]

He described how Boeing failed to highlight MCAS to FAA, Boeing's safety-critical assessment of it, and its relevant safety issues.[179] According to Mr. Jacobsen, had Boeing disclosed MCAS as a new and critical system, it would have necessitated a system safety assessment with respect to each proposed design change that FAA deemed significant, which would have delayed the overall 737 MAX schedule.[180] In addition, Mr. Jacobsen said that publicly acknowledging problems with MCAS would have required an explanation to safety regulators around the world in the form of an issue paper for which Mr. Jacobsen would have been responsible for providing relevant technical expertise.[181]

After the two crashes, Mr. Jacobsen stressed that Boeing still did not highlight MCAS or the Autothrottle Disconnect Alert issues as critical operating features that needed to be thoroughly assessed through an amended aircraft type certification.[182] With the absence of safety redundancy, pilots could face a highly unsafe scenario described by Mr. Jacobsen: erroneous airspeed, altitude, and

stall warning (stick shaker), while at the same time fighting high control forces.[183] In the end, in Jacobsen's view, Boeing minimized the importance of MCAS and kept details of its safety-critical assessment of MCAS to itself.[184]

"Changed Product Rule" allowed FAA to certify the 737 MAX according to dated airworthiness standards.

The Changed Product Rule generally requires that any modifications to an aircraft design meet the latest certification standards, regardless of the earlier certification regulation that was used to certify the aircraft being modified.[185] For example, any design changes to a component on the 737 MAX, when compared to a component on a 737 predecessor aircraft, must meet current standards. However, there is a large exception: the Changed Product Rule only applies to "significant" modifications—meaning that non-significant modifications need not hew to current standards.[186]

As a result, variants to previously approved aircraft designs, like the 737 MAX, can be certified under previous regulatory amendments using a streamlined process. Whistleblowers assert that the FAA has allowed industry applicants to make use of these exceptions under the Changed Product Rule in a manner that prevents a holistic assessment of how design changes integrate with existing systems and the associated impacts of these interactions.

Mr. Ewbank notes that Boeing sought and received an exception to 14 CFR 25.1322 via the Changed Product Rule to avoid updating the crew alerting system or having to use the Engine Indicating and Crew Alerting System ("EICAS") in the 737 MAX.[187] Mr. Ewbank explained the 737 MAX does not use the EICAS—a system designed with the latest understanding of human factors to alert flight crews and prompt appropriate reactions in critical scenarios.[188] Instead, Mr. Ewbank noted the 737 "relies on crew alerting methods developed two decades prior to EICAS that have known flaws when compared to EICAS."[189]

Mr. Ewbank observed:

> *In general, if the 737 MAX had stepped up to a full version of FAA regulations it would have resulted in a safer airplane as indicated by a reduced chance of crew error, greater chance of finding the possibility for that error during design, and creating a flight deck 'more conducive to coherent thought' in the scenarios Lion Air 610 and Ethiopian 302 encountered*.[190]

Mr. Ewbank described problems with the autothrottle system, which has a Disconnect Alert on the 737 MAX's flight deck in the form of a red flashing light and, atypically, no aural component.[191] In addition to not fitting "any of the standard alert definitions" and being absent from the 737 MAX's certification plans, Mr. Ewbank said the Autothrottle Disconnect Alert shares the same location and illumination color with the Airspeed Deviation Alert—an issue which has caused pilot confusion and safety incidents in the past.[192]

Based on his experience with the 737 MAX, Ewbank recommended that FAA take the following action to ensure the certification process produces aircraft compliant with airworthiness standards:

> *As a near-to-final certification step, the FAA would conduct a battery of system tests on actual hardware at its own facility to ensure the final aircraft design complies fully with regulations*.[193]

Mr. Dostert, a current FAA engineer, told the Committee:

> *The Changed Product rule was originally intended to force applicants to "step up" to the latest safety standards. The rule is not effective because the FAA has not required applicants to meet later standards because of the "exceptions" provision of the rule. The 737 Max flight deck was based on technology prior to 1982 (EICAS introduced on 767) and did not meet flight crew interface safety standards of §§ 25.1302 & 1322. Meeting this requirement would have prevented the accidents [of Lion Air flight 610 and Ethiopian Airlines flight 302].*[194]

Mr. Jacobsen, a former FAA engineer, spoke to the effect of the Changed Product Rule[195] on aircraft safety design. Even "significant" modifications, which under the Changed Product Rule must adhere to the most recent safety standards, may qualify for other vague exceptions, according to Mr. Jacobsen.[196]

Mr. Jacobsen claims that Boeing was able to rely on exceptions to the Changed Product Rule so as to avoid certain updated regulations, such as amendments to 14 CFR § 25.1322 concerning flight deck alerting requirements.[197] Mr. Jacobsen commented on the 737 MAX design:

> *The current 737 MAX design…[uses] a primitive flight control architecture, [and possesses] flight deck confusion vulnerabilities associated with single failures…. It passes the minimum standard*

> *and regulatory authorities are required to grant approval if the minimum standards are met*.[198]

JATR also identified that gaps associated with the Changed Product Rule and its complexity caused issues with the 737 MAX 8 certification. JATR's panel of international air safety regulators attribute the "lack of time limits or limits on the number of derivatives" under the Changed Product Rule to "allow[ing] Boeing to certify the aircraft as a fourth generation derivative" approximately 50 years after the first 737 series was certified in 1967.[199] The JATR recommended that FAA work with other civil aviation authorities to harmonize updates to the Changed Product Rule and associated guidance. To ensure FAA evaluates every aircraft design change moving forward, JATR strongly recommended that FAA use a comprehensive integrated system-level analysis that recognizes the simultaneous effect one change in complex interactive systems can have on other parts of the system.[200]

Under the *Aircraft Certification, Safety, and Accountability Act*, Congress mandated that FAA reform the Changed Product Rule, in cooperation with international partners, to require proposals for new aircraft designs (type certificates) and variants of existing aircraft designs (amended type certificates) to undergo an integrated system safety analysis that considers cumulative effects of proposed design changes to the aircraft, human factors issues, and impacts on training for pilots and maintenance personnel.

FAA approved flawed design of 737 MAX with unsafe conditions.

Mr. Jacobsen claims Boeing resisted bringing its aircraft into compliance with airworthiness requirements when deficiencies were found; and that at times, the FAA failed its obligation to ensure Boeing's compliance with airworthiness standards. Mr. Jacobsen found that, despite the Boeing ODA Unit's findings of compliance, MCAS did not meet applicable airworthiness requirements.[201] Mr. Jacobsen noted:

> *After the Lion Air crash, the emergency AD pilot procedures were inadequate and unverified. AD 2018-23-51 does not mention the possibility of an autothrottle malfunction due to an erroneous AOA input*.[202]

As discussed by Mr. Jacobsen, "the same AOA sensor failure that triggered MCAS also prevented the autothrottle from functioning correctly and transitioning to a speed protection mode as expected."[203] He stressed that MCAS did not meet several airworthiness standards and the flight deck effects in the Lion Air

crash “have previously been characterized by the FAA as unsafe, in a 2004 AD (2004-10-05).”[204] Additional airworthiness directive and design non-compliance analysis conducted by Mr. Jacobsen regarding the 737 MAX is included in the Appendix to this report.[205]

Other reported certification concerns addressed by Mr. Collins, a former FAA engineer, include allowing fuel tank surface temperatures on the 737 MAX to exceed the maximum temperature allowed by Federal Aviation Regulations (“FARs”), and a fuel pump electrical circuit protection issue.[206] Mr. Collins described the issue further:

> *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 . . . 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 housing. . . . 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 [advisory circular].”*[207]

The FAA did not prevent the 737 MAX from being certified despite this fuel pump circuit protection issue.[208] By contrast, Mr. Collins pointed out “FAA required Airbus to modify their fuel pump GFI installation before certification of the A320Neo.”[209]

FAA certified the 787 even though the aircraft was not compliant with airworthiness standards applicable to lithium ion battery failures.

Industry and FAA engineers reported to the Committee that the FAA's aircraft certification process has not consistently produced products that comply with airworthiness standards, such as with the 787 and requirements pertaining to lithium ion batteries.

As described by Mr. Collins, a former FAA engineer, the 787 did not meet the requirements of the following special conditions: "Design of the lithium ion batteries must preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure."[210] The non-compliance with the requirements is evidenced by two incidents of batteries fires. In issuing its emergency airworthiness directive ("AD") grounding the 787, FAA stated, "[t]his AD was prompted by recent incidents involving lithium ion battery failures that resulted in release of flammable electrolytes, heat damage, and smoke on two Model 787-8 airplanes."[211]

On November 21, 2014, the National Transportation Safety Board ("NTSB") completed its investigation of the January 2013 incident involving Japan Airlines 787.[212] Among its findings, NTSB determined that Boeing ODA unit members and FAA certification engineers failed to communicate key assumptions and risks related to battery thermal runaway events.[213] And Boeing ODA's safety assessments failed to uncover design vulnerabilities related to thermal runaway events.[214] FAA similarly failed when approving Boeing certification plans and proposed methods of compliance.[215] As a result, Boeing ODA unit members and FAA certification engineers did not conduct qualification tests to demonstrate that the 787's design met the applicable airworthiness requirements: that "design of the lithium-ion batteries must preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure."[216]

The subsequent grounding of the 787[217] cost Boeing $600 million and the safety fixes for U.S. airlines cost approximately $2.8 million in addition to lost revenue from grounded aircraft. [218] For example, Japanese carriers All Nippon Airways and Japan Airlines estimated a combined $110 million in lost operating profits from the 787's grounding; Qatar Airways claimed revenue losses of $200 million.[219]

Mr. Dostert, the current FAA engineer, observed that Boeing has "refused or delayed certain design changes identified by FAA safety engineers prior to type design approval," and that "Boeing has not been required by the FAA to bring the airplane into compliance when non-compliances are discovered following initial

certification."[220] Mr. Dostert framed this as Boeing being "rewarded for not developing a compliant design."[221] As a solution, Mr. Dostert recommended:

> *Mandating that all non-compliances are fixed in production and retrofitted into previously produced airplanes would provide a big incentive for companies to produce a compliant design since the post certification cost to fix the known non-compliance would well exceed the initial cost. Currently there is a provision in the ODA criteria for the holder to disclose non-compliances, but Boeing is not required to bring the airplanes back into compliance and the provision does not require retrofit of the changes*.[222]

V. STRONG FAA OVERSIGHT HAS ERODED UNDER THE ODA PROGRAM.

The ODA program changed the relationship between FAA and the manufacturer's engineers acting on behalf of the agency.

Multiple whistleblowers whom came before the Committee spoke to differences in compliance oversight between the FAA's prior Designated Engineering Representatives ("DER") program and current ODA program. Such differences can be characterized by how these systems affect an individual aircraft manufacturer engineer. As an ODA unit member, an individual engineer is farther removed from direct FAA oversight than a DER, who was directly monitored by an FAA engineer. Due to this difference, ODA unit members are left more vulnerable to the possibility of undue pressure or interference by the ODA holder – the aircraft manufacturer – than DER, who were less susceptible to such influence under the DER system framework.

Mr. Dostert, an FAA engineer, explained that "instead of using its oversight authority, the FAA relied on a flawed ODA concept and allowed Boeing to cut corners and eliminate layers of protection, violating the fundamental 'fail safe' concept of aviation safety."[223] According to Mr. Dostert, there is a stark contrast between the prior DER system, in which FAA had much greater oversight over delegated authority, and the ODA system:

> *The current [ODA] system is based upon the assumption that the organization within the company can effectively operate as an independent branch within the company that will force the company to comply with regulations. The ODA selects Authorized Representatives (ARs), determines proficiency/competency, regardless of turnover in the organization and organizational pressures within the company to meet certification schedules. In addition, the Boeing ODA has a group review of specific issues that has resulted in many ARs not wanting to speak up due to a "group think" phenomenon. The fundamental assumptions that form the basis of the ODA are flawed. . . . [T]he current system puts barriers to open communication with the FAA. In fact Boeing has an internal requirement that ARs must obtain permission to contact the FAA. . . . Boeing has demonstrated their ODA is not forcing the company to produce a compliant design.*[224]

A key reform in the *Aircraft Certification, Safety, and Accountability Act* is ensuring more direct FAA oversight of the ODA and individual unit members, as similarly found under the DER system. This includes FAA approval and removal of the manufacture's engineers acting on behalf of the FAA and the assignment of FAA safety advisors to supervise their performance and ensure direct communications of safety concerns.

FAA is responsible for determining compliance with safety standards in the certification process.

Since at least the *Civil Aeronautics Act of 1938*, Congress has authorized the FAA and its predecessor agencies to issue aircraft design approvals (type certificates) *only when* the *FAA* finds, among other criteria, that the design "meets the minimum standards, rules, and regulations prescribed."[225]

Specifically, 49 U.S.C § 44704 provides:

> *The Administrator of the Federal Aviation Administration shall issue a type certificate…when the Administrator finds that the aircraft, aircraft engine, propeller, or appliance is properly designed and manufactured, performs properly, and meets the regulations and minimum standards prescribed under section 44701(a) of this title.*

Under 49 U.S.C. § 44701(a), the Administrator of the FAA:

> *Shall promote safe flight of civil aircraft in air commerce by prescribing—*
>
> *(1) minimum standards required in the interest of safety for appliances and for the design, material, construction, quality of work, and performance of aircraft, aircraft engines, and propellers.*

An aircraft's "type certificate" demonstrates that a product complies with FAA standards.[226] The type certification process involves FAA's approval of the manufacturer's design of the aircraft and all component parts (including propellers, engines, etc.) following the applicant's demonstration and FAA's determination of compliance with the prescribed regulations, including airworthiness standards, and to ensure continued operational safety.[227]

In the certification process leading to a type certification, FAA authorizes a qualified person or organization to perform certain duties on behalf of the FAA.

The Federal Aviation Act of 1958, establishing the agency, authorized the FAA to delegate activities under section 314 of the Act. That provision is found at 49 U.S.C. § 44702(d), provides:

> *(1) Subject to regulations, supervision, and review the Administrator may prescribe, the Administrator may delegate to a qualified private person, or to an employee under the supervision of that person, a matter related to—*
>
> > *(A) the examination, testing, and inspection necessary to issue a certificate under this chapter; and*
> >
> > *(B) issuing the certificate.*

The statutory provisions for FAA authority for certification and ability to delegate are intended to be complementary; FAA's ability to delegate does not in any way diminish its responsibility to find compliance with applicable standards as the prerequisite for issuing certificates under 49 U.S.C. § 44704(a). Indicating perseverance of FAA's primary role, individuals holding delegated authority are commonly referred to as "representatives of the Administrator" and "designees."[228]

FAA has relied on the 1984 *Varig Airlines* case as a basis for delegating certification authority to industry even though the precedent pertained to tort liability.

The purpose of FAA's aircraft certification authority is not to delegate responsibility as a means of avoiding liability; the statutes are designed to ensure that an aircraft is properly designed and manufactured, performs properly, and meets the regulations and minimum standards prescribed by the FAA in the interest of safety.[229]

FAA claims that the "U.S. Supreme Court has consistently affirmed the right of U.S. government agencies to apply discretion in regulatory oversight through the 'discretionary function' exception of the Federal Tort Claims Act." [230] FAA, for example, in its "AIR Transformation" website currently cites this "discretionary function" as the basis to determine the level of FAA or designee involvement for reviewing substantiating data for compliance during certification.[231]

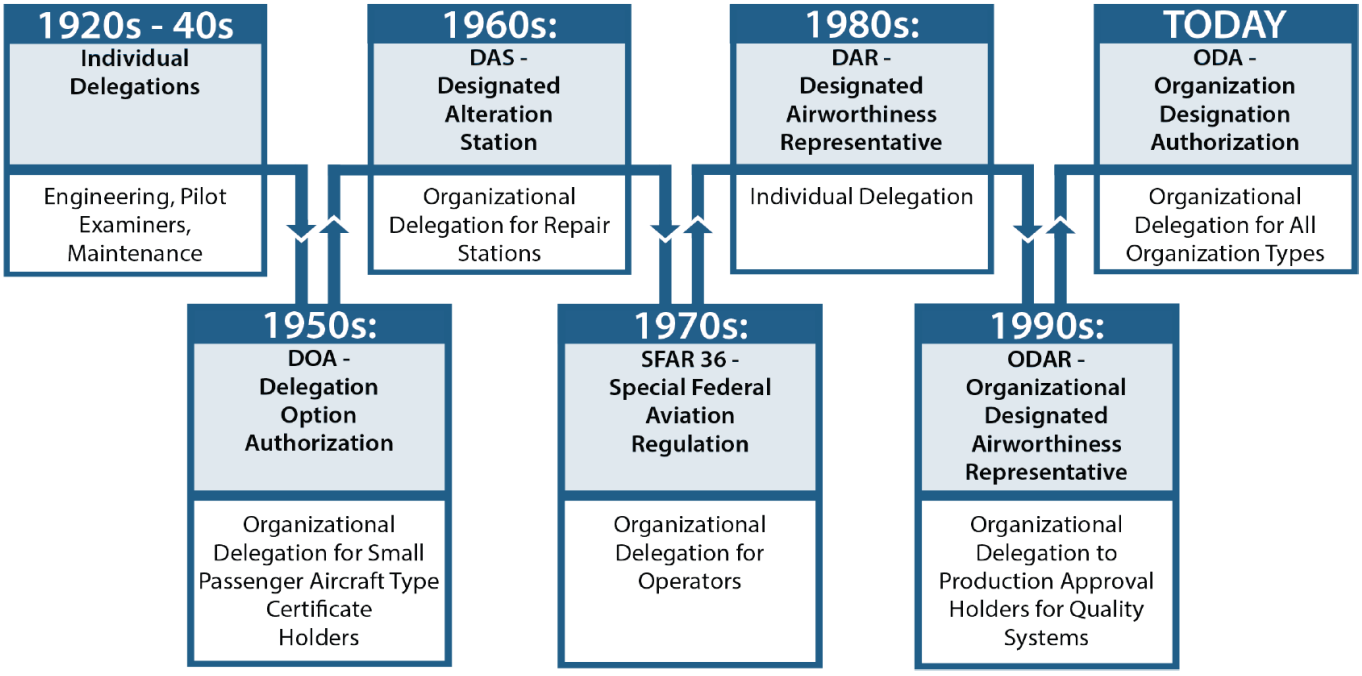
In 1984 the U.S. Supreme Court issued its decision in *United States v. Varig Airlines ("Varig Airlines")*, holding that FAA could not be held liable for issuing a type certificate for the Boeing 707 when the design did not meet the applicable

airworthiness standards. [232] The airworthiness non-compliance in this case had resulted in an accident on the Varig Airlines flight in which 124 of the 135 persons on board died.[233]

In *Varig Airlines*, the court found that FAA's type certification process qualified for an exception under the Federal Tort Claims Act,[234] because it is a "discretionary function" in that FAA has the ability to determine to what extent it will review the applicant's design data.[235] The discretionary function exception exempts the United States Government from liability for damages arising from the use or abuse of discretionary government powers.[236]

While FAA reference to the "discretionary function" exception is legally correct vis-à-vis FAA's potential tort liability for approving non-compliant designs, this reliance and the resulting policy decisions do not correctly reflect Congress's statutory intent for safety oversight. FAA is statutorily required to determine compliance with safety standards in the certification process.

Figure 1: History of Aviation Delegation Programs[237]



FAA's system of delegation has involved individual designees and organization-level delegation.

Prior to the ODA program, FAA's system of delegation mainly involved delegation to individuals, such as Designated Engineering Representatives ("DERs"), non-FAA persons considered industry experts in their particular disciplines.[238] DERs were assigned "safety advisors," FAA employees with similar expertise, who were responsible for working with their DERs and monitoring their performance to ensure they were properly implementing FAA policy in making compliance findings on behalf of the FAA.[239] DERs were appointed on a periodic basis (usually annually) with no right of renewal, so if their FAA advisor was dissatisfied with their performance, their designation could be allowed to expire or even be terminated.[240]

In addition to individual designees, FAA also established organizational delegations for various limited purposes,[241] including approving designs for small aircraft (1950's Delegation Option Authorization), major alterations (1960's Designated Alteration Station), and major repairs (1970's SFAR 36 Authorization).[242]

FAA saw a need for regulatory change as its certification workload expanded and its reliance on designees increased alongside the growth of the aviation industry.[243] The FAA established the Aviation Rulemaking Advisory Committee (ARAC) in 1991[244] to provide a mechanism for industry and public engagement in the regulatory process, including in the area of aircraft certification.[245]

In 1993, FAA created the Delegation System Working Group of the ARAC to develop a proposal to consolidate and broaden the scope of these organizational delegations.[246] FAA tasked the industry advisory group with developing a "systematic approach" for delegating aircraft certification functions to both individuals and organizations.[247] FAA also charged the New Delegation System Working Group with recommending new rules to provide a comprehensive replacement of prior organization-level delegations like SFAR 36 and expand to new organizations.[248]

In 1998, FAA expanded the task of the Delegation System Working Group to include recommendations on designating organizational Designated Airworthiness Representatives (DARs) and evaluating organizations that would be designated to find compliance for various FAA certificates.[249] FAA explained that it was seeking input on systems "compatible as practicable with the systems used by the civilian aviation authorities of other countries" including its trading partners in Europe and Canada.[250]

In 2004, FAA introduced new rulemaking to move to a new organization-level delegation, the ODA program.

On January 21, 2004, FAA published a notice of proposed rulemaking ("NPRM") to adopt the Delegation System Working Group's recommendations by establishing regulations for Organization Designation Authorizations ("ODAs").[251]

FAA issued the final rule in October 2005 establishing the ODA program.[252] The final rule provided a three year period starting on November 14, 2006, for existing organizations with delegated authority – Designated Alteration Station, Delegation Option Authorization and Special Federal Aviation Regulation 36 authorization programs – to transition to the ODA program.[253]

According to the FAA rulemaking, the ODA program was intended to improve the efficiency of the certification process by relying on the expertise of the delegated organization, rather than on any individuals within the organization, to perform the detailed reviews of design data necessary to find compliance with airworthiness standards.[254] FAA described its role as being limited to overseeing the ODAs' "systems," rather than the performance of individual designees:

> *Organizational designees are managed using a systems approach, which relies on the experience and qualifications of the organization, approval of the procedures used by the organization and oversight of the functions the organization performs. Thus, the FAA can focus on that organization's delegated functions as one system, rather than concentrating on monitoring and supervising individual designees. Such partnerships with industry leverage the abilities of industry and maximize the effectiveness of the certification process for both the FAA and the organization.*[255]

FAA recognized that this systems approach required it to have confidence in the ODA holder based on certain requirements:

> *The proposed rule provides safeguards to ensure the integrity of the ODA Holder. The proposal requires the ODA Holder to perform self-audits and ensure that no one interferes with individuals performing functions for the FAA. These terms are in addition to current authorization requirements for procedures manuals, recordkeeping, inspections, and data review if an airworthiness problem or unsafe condition occurs. ODA Holders would also be required to cooperate with the FAA in its audit, oversight, and surveillance of their*

> *facilities…. The administration of the ODA Unit would be independent of other parts of the organization whose work the ODA Unit is reviewing and, therefore, the ODA Unit may not be subjected to pressure by any other part of the organization.*[256]

The National Air Traffic Controllers Association ("NATCA"), representing the FAA's air traffic controllers, engineers, and other aviation safety-related professionals, raised serious concerns with the proposed ODA program:

> *The proposed ODA NPRM and Order significantly modify the current regulatory oversight system by deteriorating the established FAA oversight system by going to a "systems" oversight approach that provides less specific and technical FAA oversight and therefore would in time lower the safety of the flying public.*[257]

The agency rejected any such assertion:

> *The FAA disagrees that a systems approach will provide less specific technical oversight, and believes it will increase safety… by freeing up FAA resources for tasks more critical to safety*.[258]

FAA acknowledged that the ODA program would involve "increasing the number of delegations to organizations," but FAA explained that this would prepare industry and the FAA for future certification programs, such as the Certified Design Organization ("CDO").[259] The CDO concept, according to FAA, would make manufacturers responsible for ensuring the systems they design and manufacture comply with all FAA requirements.[260] The FAA would rate qualified certificate holders according to their experience and allow them to make the approvals necessary for the certification of the projects they manufacture. [261] FAA concluded that the "system management" concepts implemented under ODA could serve as a basis for CDO structure and management. [262]

Through the *Aircraft Certification, Safety, and Accountability Act*, Congress repealed the "certified design and production" ("CPDO") authority and made clear that aviation manufacturers will not be able to self-certify their own aircraft, aircraft engines, and propellers.[263]

As FAA implemented the ODA program, there were reports of safety experts troubled by the shift to self-regulation.

Government watchdogs also studied the ODA program's implementation. In October 2004, the Government Accountability Office ("GAO") issued a report, "FAA Needs to Strengthen the Management of Its Designee Programs," warning that it was especially important that FAA improve the oversight of its designee programs as the agency moved forward with the ODA program.[264] This was because the shift would expand the number and types of organizational designees and further transform FAA's role to that of monitoring the performance of organizations rather than overseeing the individuals who perform the certification activities.[265] As part of its 2004 report, GAO's top ranked recommendation for improving FAA oversight was holding designees accountable for their findings through consistent evaluation and monitoring of designee activities.[266]

As FAA rolled out the ODA program in 2008, Dominic Gates of *The Seattle Times* published reports that warned about potential problems with the ODA program.[267] For a September 2, 2008 article, Mr. Gates interviewed Tomaso DiPaolo of NATCA, the union that represents air traffic controllers and about 600 aircraft-certification technical experts at the FAA, said the new system "hands the keys over to the companies." [268] DiPaolo said the union was worried about reduced oversight of safety issues.

> **"The federal government, because of shrinking resources, is turning over key parts of transportation-safety oversight" to private industry, said Jim Hall, a former Chairman of the NTSB, in an interview. "History tells us this could be a very dangerous path."**
>
> - *Dominic Gates, "FAA lets aerospace firms certify safety of their products," The Seattle Times, September 2, 2008*

Mr. Gates also spoke with Jim Hall, a former NTSB chairman, who criticized the new approach.[269] One FAA-certification engineer who remained anonymous due to fear of losing his job said that inserting a layer of company management between him and the company's engineers increased "the chance of undue pressure" on those doing the detailed engineering reviews.[270]

On August 20, 2009, Mr. Gates wrote an article titled "FAA extends Boeing's authority to self-certify aircraft."[271] He reported that under the agency's new safety oversight model, Boeing manufacturing and engineering employees will perform delegated tasks for the FAA, including signing certificates approving new designs.[272]

> *Though appointed by and accountable to the FAA….The new system increases the authority of the in-house inspectors directly managed by Boeing, allowing them to review new designs, oversee testing to ensure the products meet all applicable standards, and sign off on certification.*[273]

In 2011, DOT OIG issued an audit report, "FAA Needs to Strengthen Its Risk Assessment and Oversight Approach for Organization Designation Authorization and Risk-Based Resource Targeting Program."[274] The DOT OIG warned that FAA would experience the same vulnerabilities the agency had with past-designated organizations – which had either neglected a critical rule or did not properly demonstrate compliance, calling into question how adequately FAA reviews new engineering project plans submitted by delegated organizations.[275] The report found that with FAA no longer in charge of approving individual designated engineers like under the DER system, the ODA company could appoint unit members with inadequate qualifications or a history of poor performance to approve certification projects.[276]

In 2012, FAA formed an industry advisory group that promoted increased delegation in the FAA certification process.

In May 2012, the FAA established an Aviation Rulemaking Committee ("ARC") co-chaired by Ali Bahrami, Manager of FAA's Transport Airplane Directorate along with industry trade groups, to make recommendations on methods for enhancing the effective use of delegation systems, including organizational designation authorization.[277] Section 312 of the FAA Modernization and Reform Act of 2012 had called on FAA to conduct an assessment of the certification process.[278]

The ARC endorsed the "Accountability Framework," in which applicants are fully responsible for compliance with airworthiness standards, and FAA is responsible for establishing the requirements.[279] Under this framework, the ARC recommended that FAA use its "discretionary function" (from the *Varig Airlines* case) to rely on and conduct oversight of applicants' systems, with the objective of "fully utilizing" delegation: "Discretionary function through risk-based level of involvement allows the FAA to delegate *any and all* compliance findings."[280]

A central thesis of the ARC report is that FAA should further reduce its involvement in reviewing applicants' designs and should instead rely on a "systems oversight" approach to improve "effectiveness and efficiency" of the certification process.[281] The ARC selectively chose prior reports and recommendations to find a "common theme" to support "shifting the FAA certification process from a detailed product approach toward a systems safety approach."[282] This included expansion of the delegation program, which would allow the FAA to more "effectively" perform its safety oversight while "significantly improving certification process efficiency, which reduces the time, burden, and cost impact on industry."[283]

The ARC recommended that FAA move towards implementing the CDO concept, which would enable applicants to approve their own designs without the involvement of FAA or its designees.[284] The ARC found this move "a natural progression of the maturity and capability of organizational delegation that provides a significant opportunity for improvements in safety, safety culture, and the overall effectiveness and efficiency of aircraft certification processes."[285] The FAA would parrot this language of "natural progression" of further organizational delegation when appearing before Congress.[286]

Another ARC report in 2012 further encouraged this approach relying on applicants to ensure that products would conform to their approved designs.[287] The ARC concluded: "Unless valid reasons exist to withhold complete delegation, a project should be delegated."[288] The ARC envisioned a phased transition, over a seven-year period, leading to a "Transformational" stage involving self-certification of aircraft through certified designated organizations.[289]

In 2015, FAA and industry implemented plans and metrics to prioritize efficiency through delegation in the certification process.

In 2015, the FAA adopted a "Detailed Implementation Plan," which describes how it will improve the "effectiveness and efficiency" of the certification process by achieving "full utilization" of delegation[290] and replacing FAA review of design data with a "system safety approach."[291] In reference to the meaning of "effective," the FAA explained its intentions:

> *The action plan outlines specific actions needed to increase the efficiency of ODA certification processes including; full utilization of ODA authority, increased FAA focus on ODA-related workload, updating of FAA procedural requirements, and identifying training needs for FAA personnel*.[292]

The FAA implementation plan includes development of metrics to measure the "effectiveness" of FAA's ODA processes.[293] Beginning in 2016, FAA, in collaboration with industry, developed an "ODA Scorecard" using jointly developed metrics. [294] These metrics were designed to "help identify appropriate opportunities to further improve the utilization of ODA and reduce FAA involvement in the critical path" in the certification process.[295]

The ODA Scorecards are based on surveys of industry stakeholders and of FAA offices charged with overseeing ODAs. [296] The ODA Scorecards suggested that certification efficiency as the top priority, as compared to regulatory compliance. For example, regulatory compliance metrics are based on self-disclosed non-compliances by applicants compared to non-compliances identified by FAA: "[t]he goal is to show a year-to-year decrease in the percentage of Non-Compliances found by FAA in comparison to those identified by the company."[297]

Other guidance from the FAA, such as a "Refresh Certification Strategy" indicate a similar goal with a de-emphasis on "compliance" with FAA standards as part of aircraft certification.[298] To gain efficiencies, FAA is removed from the "critical path to certification."[299]

Later investigations would find "weaknesses" in FAA's certification and delegation processes hindered FAA oversight of the 737 MAX.

In its February 2021 report, "Weaknesses in FAA's Certification and Delegation Processes Hindered Its Oversight of the 737 MAX 8," DOT OIG identified numerous oversight issues in areas ranging from FAA's guidance for FAA certification engineers to resource gaps and concerns of undue pressure at Boeing's ODA.[300]

DOT OIG highlighted how the FAA embraced a "systems oversight" approach to regulation of the design and manufacturing aircraft.[301] Rather than focusing on individual project engineering work, "systems-based oversight" shifts to assessing whether designated companies with delegated authority from the FAA collectively have the people, processes, procedures, and facilities in place to produce safe products.[302] This shift from the statutory requirement to find compliance with airworthiness standards towards a finding systems oversight may be based on mistaken assumptions about the independence of ODA unit members who act on behalf of the FAA, yet remain employees of the applicant company.

Issues with the ODA structure could lead to conflicting duties and undue pressure for ODA unit members, according to DOT OIG.[303] Since the ODA's system of delegation charges the delegated organization with assessing data necessary to determine its own compliance with FAA airworthiness standards, the risk of undue pressure or interference, which could pressure an individual engineer to approve an aircraft design that may not comply with FAA regulations, is inherently greater. DOT OIG concluded that FAA's ODA program "does not prevent conflicting duties of ODA unit members" and does not include specific guidance to define what qualifies as "conflicting" ODA unit member duties.[304]

Finally, DOT OIG found that weaknesses in FAA's delegation system led to a "significant misunderstanding" of the MCAS, the flight control software identified as contributing to the two 737 MAX accidents.[305] DOT OIG found that although initially FAA had only delegated 32 percent of detailed certification plans to the Boeing, by the end of the process, in February 2017, FAA eventually delegated all 91 certification plans to Boeing's ODA, including the flight controls and stabilizer plans containing MCAS.[306] As a result, key FAA personnel lacked an adequate understanding of how and when MCAS activated, its interaction with other key systems on the 737 MAX, and the potential risks associated with multiple erroneous MCAS activations on a flight.[307]

In 2017, FAA certified the 737 MAX utilizing the new system of delegation reliant on Boeing's ODA to make critical compliance findings. Specifically, FAA approved the amended type certificate for the 737 MAX-8 on March 8, 2017, and the amended type certificate for the 737 MAX-9 was approved on February 15, 2018. On October 29, 2018, Lion Air Flight 610, a 737 MAX-8, crashed shortly after take-off, killing all 189 people aboard. On March 10, 2019, Ethiopian Airlines Flight 302, also a 737 MAX-8, crashed shortly after take-off, killing all 157 people aboard. On March 13, 2019, FAA issued an "Emergency Order of Prohibition" grounding the 737 MAX.

The 737 MAX crashes resulted in the tragic loss of 346 lives. The grounding of the aircraft have also had a significant impact on U.S. aviation manufacturing and safety oversight. The direct cost to Boeing is estimated at more than $20 billion,[308] which does not even account for harm to the U.S. aerospace supply chain and reputation harm suffered by the FAA. The agency had to effectively re-certify the airplane through intensive safety review process spanning nearly 2 years, and 737 MAX customers were forced to make design changes and provide flight crew simulator training.[309] It was the outcome that Boeing had initially intended to avoid[310] with the FAA's streamlined certification of the 737 MAX under the ODA program.[311]

VI. COMPLEX AIRCRAFT SYSTEMS INVOLVING HUMAN FACTORS AND AUTOMATION PRESENT NEW CHALLENGES FOR THE FAA AND INDUSTRY.

FAA faced challenges with technical capability and human factors expertise when certifying the 737 MAX.

According to whistleblowers, with increasingly complex flight control systems and emerging technologies, the FAA had difficulty properly assessing the intersection of automation and human-machine interfaces.

Mr. Ewbank stressed to the Committee that the 737 MAX was not originally designed and certified to consider "human factors" in the flight deck (i.e., the effect of human response to various alerts in the greater flight controls system), nor did it meet regulatory standards or implement "a modern concept of aviation safety."[312] He highlighted the importance of "a holistic, scientific approach to ensure each pilot is presented with a consistent, salient flight deck and airplane" as pilots attempt to process and understand an aircraft's various automated functions and the aerodynamic state of the airplane to safely fly.[313]

Mr. Ewbank asserted that the FAA faced challenges with having the technical capability and human factors expertise to be able to certify increasingly complex aircraft systems.[314]

> *Airplanes are complex systems, and such knowledge-in-depth is required to fully understand the practical effects of the certification process and regulations. Unfortunately, many of the high-level decision makers and representatives of Boeing and the FAA do not have this working knowledge…*[315]

Mr. Ewbank noted that the Autothrottle Disconnect and Airspeed Deviation alerts have caused pilot confusion in the past.[316] Increased technological complexity of aircraft systems can add to challenges pilots face during flight.[317] According to Ewbank, even the most experienced pilots can be inundated with multiple alerts in the flight deck that can be difficult to process.[318] He speaks to this technological variable and the considerations a pilot makes to be able to maintain flight safety:

> *That complexity stems from the nature of the pilot's task of integrating an understanding of automated functions and the aerodynamic state of the airplane; a pilot uses everything from indicators, control force feel, "seat of the pants," prior experience, and training to develop appropriate responses to whatever situation arises*.[319]

Mr. Ewbank also stressed the need for FAA to improve oversight capacity to respond to and certify evolving flight controls technology and stated:

> *…had the 737 MAX been certified to a full set of FAA regulations it would have been a safer airplane merely by entering the market with the most up-to-date understanding of system design and critical human-machine interfaces. Current FAA regulations require this understanding; during development of the 737 MAX Boeing sought ways to rationalize not updating the aircraft systems to that level, and the FAA permitted it to do so. The result is 346 lives lost*.[320]

Mr. Ewbank recommended a "thorough revamp of all FAA regulations to ensure they reflect a modern understanding of computer technology and human-machine interfaces."[321] Mr. Ewbank noted this recommendation "create[s] a requirement for a significant amount of technical knowledge at the FAA."[322] He suggested that FAA consult with other federal agencies, such as the National Aeronautics and Space Administration ("NASA") and the Department of Energy:

> *If the FAA prefers to remain focused on finding regulatory compliance only, it may be better to perform these tasks in a separate public institution such as a NASA center or National Laboratory. Such a technical center focused on end-to-end evaluations of automation and human interfaces with automated systems would have public safety benefits beyond aviation….to operate complex systems in high-risk environments*.[323]

Aviation manufacturers are competing for engineers and technical experts to further innovation in aircraft systems.

The pandemic-era economy has disrupted the workforce and aviation manufacturers face increased competition for the requisite engineers and technical experts to further innovation. According to the Aerospace Industries Association, the civil aviation sector's workforce shrunk by 87,000 jobs in 2020, due in large part to the COVID-19 pandemic.[324] However, according to a survey

of recent information technology and engineering graduates, aerospace ranked below computer software and technology as a preferred industry to work in, with no aerospace employers ranking the top 50.[325]

Other manufacturers face this workforce problem. In July 2021, Bloomberg reported on a "brain drain" at Boeing, a product of the manufacturer's goal to cut 23,000 jobs due to COVID-19 coupled with engineers leaving for competitors, such as Amazon and its subsidiary PrimeAir and commercial space rivals SpaceX, Blue Origin, and Virgin Galactic.[326] More specifically:

- More than 3,200 engineers and technical workers have left Boeing's Seattle manufacturing hub since the start of 2020, including 274 "technical fellows"—a selective technical leadership career path;[327]
- At least 1,100 former Boeing employees now work for Amazon or one of its subsidiaries, and at least 200 now work for Blue Origin;[328] and
- Some of Amazon's hires include senior executives who previously held leadership roles at Boeing, including the former chief engineer of the 787 Dreamliner.[329]

According to Bloomberg, Boeing has responded in part through internal promotion like giving 264 employees the sought-after "technical fellow" designation, even though in some years only a dozen or so engineers received that promotion.[330] This reporting underscores that staffing is not just a quantity challenge, but also a quality challenge:

> *Software design and coding errors [at Boeing] have repeatedly led to performance shortfalls, like the faulty system that commanded the 737 MAX to dive, KC-46 tanker's fueling glitches and delays to the 777-X jet's debut. They also caused the Starliner capsule to miss a rendezvous with the International Space Station on its first flight in 2019.*[331]

Manufacturer's like Boeing must also solve difficult software issues. A May 13, 2021 letter from Ian Won—acting manager of the BASOO—to Boeing highlights challenges presented by increasingly complex aircraft.[332] In the letter, Mr. Won told Boeing that it is unlikely that the 777-X would be certified until "mid to later 2023" due in part to software problems identified by FAA.[333] The Common Core System ("CCS"), the 777-X software in question, is described as a very complex and critical avionics system. According to the BASOO's assessment, the CCS "provides the means for hosted functions of all criticalities to safely share the same physical resources," and is a significant technological change from the baseline software on the 777-300ER.[334] Mr. Won identified recent changes

made to the 777-X's software that could cause new, inadvertent problems.[335] As a result, the BASOO determined that the aircraft was not yet ready for type inspection authorization ("TIA") as the aircraft type design was not yet at a point where it could be expected to meet applicable regulations.[336]

The loss of technical expertise at GE Aviation has also had a real-world impact, according to Mr. Kucera. For instance, Mr. Kucera noted in 2020 GE Aviation hired a new lead administrator for its production certificate ODA program who had "no background in FAA delegation" yet was replacing someone "steeped in the FAA delegation system" who had accepted an incentivized retirement package as part of COVID-19 related downsizing at GE Aviation.[337] In fact, "all of the most experienced" production certificate ODA unit members "were either laid off or took early, incentivized retirements when GE Aviation shrank as a company during the COVID-19 pandemic (in 2020 and early 2021)."[338] As a result, the GE's production certificate ODA "was severely understaffed" such that Mr. Kucera found it "quite challenging to maintain the integrity of the GE ODA's FAA conformity determination capability under these conditions."[339]

Automated flight systems have enhanced safety and created new challenges.

According to the FAA, in the 20 years prior to 2018, commercial aviation fatalities decreased in the United States by 95 percent as measured by fatalities per 100 million passengers.[340] Worldwide, the accident rate among scheduled commercial passenger operations for the 10-year period from 2008 through 2017 was 0.44 accidents per 100,000 flight departures, or roughly one accident in every 227,272 departures.[341] A 2019 report from the Congressional Research Service (CRS) observed that the "safety record of commercial airlines operating transport category airplanes is unsurpassed among modern transportation systems."[342]

Although automation made major contributions to improving aviation safety generally, it also created risks that must be addressed. The 2019 CRS report describes this challenge:

> *Many aviation safety experts attribute the safety advancements in commercial aviation over the past three decades, at least in part, to improvements in aircraft systems technology and flight deck automation. Paradoxically, these same factors have been implicated as causal or contributing factors in several aviation accidents and incidents.*[343]

Before the introduction of automated flight systems, pilots generally referenced the raw data generated by onboard instruments—such as airspeed, altitude, pitch, and heading—to manually maneuver the aircraft. Modern airplanes have since incorporated advanced autopilot features and flight controls that interface directly with onboard computers to maneuver the plane.

Over the past three decades, pilots have become increasingly reliant on automated software to fly.[344] This trend towards automation has created a safety paradox. While advanced flight guidance software may decrease pilot workload and better prevent accidents, it can also introduce new vulnerabilities if the technology malfunctions or pilots misinterpret how the automated systems interface with the aircraft.[345] Adding considerably to the impact of this shift to automation is the failure of FAA's oversight and certification processes to provide necessary scrutiny as software and automated features evolve.[346] The devastating outcome of this paradox was witnessed in the two 737 MAX crashes. Left unaddressed, the overreliance on automated flight systems coupled with FAA's flawed oversight could continue to put the flying public and the men and women in the aviation workforce at risk.

Over the past two and a half decades, there have been multiple aviation accidents in which aircraft flight deck automation has been cited as a causal or contributing factor. Human error can further exacerbate risk from automated features on aircraft flight deck systems: human error has been documented as a primary contributor to more than 70 percent of commercial airplane hull-loss accidents.[347] More generally, we have seen a trend away from machine failures towards problems of human factors.[348] In aviation, human factors involve understanding how humans can most safely and efficiently be integrated with technology such as the design of automated flight control systems. [349]

According to data collected by the National Transportation Safety Board ("NTSB"), of the 970 accidents among large domestic and foreign carriers since 1995, 23 accidents (2.4%) involved an automation issue.[350] For the 47 fatal accidents over the same period, automation was a contributing factor in six cases (12.8%).[351]

The data obtained by the NTSB reveal two troubling trends concerning the role of automation in fatal crashes among large domestic and foreign carriers. First, of the total number of fatal aviation accidents since 2005, a higher share have been attributable to automation in recent years. For instance, in 2005 there were 3 fatal aviation accidents but only one accident was attributable to automation (33%).[352] In 2013, there were also three fatal accidents, and two of them (66%)

were attributable to aviation.[353] Similarly, in 2019 there were two fatal aviation accidents and one of them was due to aviation (50%).[354]

Second, the NTSB data reveals that of the aviation accidents attributable to automation, a larger share have been fatal in recent years. For example, of the two accidents attributable to automation in 2005, only one was fatal (50%).[355] By comparison, in 2013, there were two accidents attributable to automation and both were fatal (100%).[356] Similarly, in 2019, the one accident attributable to automation was also fatal (100%).[357]

These incidents reveal that the increasing complexity of modern flight deck automated systems can exacerbate safety risks in a variety of ways.

Pilot Understanding of Automated Flight Systems

Pilots may fail to fully understand how the automated flight guidance systems interface with the aircraft. For example, on April 26, 1994, China Airlines Flight 140 crashed while attempting to land in Nagoya, Japan, killing 264 passengers.[358] A post-accident analysis found that Flight 140 stalled after the pilot inadvertently triggered the autothrottle feature during the plane's final approach.[359] Because the autothrottle function differed from the previous planes the pilot had flown, and also from the training simulations the pilot had completed, the flight crew did not know how to deactivate or manually override the autothrottle software.[360]

A similar miscalculation led to the crash of Asiana Airlines Flight 214 near San Francisco International Airport on July 6, 2013, an accident that killed three passengers and seriously injured 49 more. [361] After an investigation, the NTSB concluded that the accident resulted from the pilots' misunderstanding of how the plane's autopilot and autothrottle systems functioned.[362] Specifically, as Flight 214 made its final approach, the flight crew manipulated the autopilot and throttles in a manner that—without their realization—deactivated the autothrottle function and caused the plane to quickly lose altitude and speed. Following the accident, the NTSB called for an examination of automated flight systems and issued recommendations to improve pilots' understanding of the autothrottle system at issue.[363]

The failure of pilots to correctly operate automated flight systems has also been a contributing factor in other aviation accidents. Recently, three crew members were killed when an Atlas Air cargo plane crashed in Trinity Bay, Texas.[364] The NTSB found that despite various visual cues in the cockpit, the pilots did not

realize that they had inadvertently caused the plane to switch to an automated flight path different from what they expected.[365]

Similarly, on October 14, 2004, Pinnacle Airlines Flight 3701 crashed in a residential area in Jefferson City, Missouri after the pilots switched the aircraft to an autopilot vertical speed mode that triggered an aerodynamic stall and killed the two pilots on board.[366] After an investigation, the NTSB concluded that due, in part, to the pilots' inadequate training, the flight crew misused the aircraft's automation features which allowed the airplane to reach 41,000 feet in a critically low energy state.[367]

Technology Malfunctions

Even when pilots understand how to operate an aircraft's automated systems, the sensors on which complex aviation software rely can malfunction and generate faulty data which, in turn, can adversely affect the flight.

Lion Air Flight 610 and Ethiopian Airlines Flight 302 offer sobering examples of how erroneous data can corrupt automated flight systems and lead to disastrous consequences. Flight 610 and Flight 302 were each equipped with the Boeing 737 MAX Maneuvering Characteristics Augmentation System ("MCAS"), an automated system which relied on aircraft pitch data from the planes' angle-of-attack sensors on the fuselage.[368] As designed at the time, if the MCAS system sensed that a plane was in a nose-high position, it would attempt to autocorrect by repositioning the nose of the plane downwards. For Flight 610 and Flight 302, aviation experts believe that the MCAS systems engaged because the planes received faulty data from the angle-of-attack sensors which incorrectly indicated that the aircrafts were in a nose-high pitch position.[369] When the pilots attempted to counteract the MCAS system by manually pointing the nose of the plane upwards, the MCAS system would reset and then automatically re-positioned the nose downwards.[370] Thus, despite the pilots' attempts to manually override the MCAS system, both planes ended in nosedives, killing 346 people across both flights.[371]

Air France Flight 447 offers another example of the challenges presented when faulty data providing automated flight systems with inaccurate information about the plane's altitude, speed, or position. On June 1, 2009, Flight 447 was traveling from Rio de Janeiro to Paris when it crashed into the Atlantic Ocean, killing 228 passengers.[372] An investigation by French authorities revealed that key sensors had become covered in ice during the flight, causing inconsistent airspeed readings that prompted the flight software to disconnect the autopilot feature and disable protections against aerodynamic stalls.[373] The pilots, failing

to realize that the plane was operating pursuant to data from degraded sensors, were unable to take corrective action and ultimately suffered a sustained stall that ended in a crash.[374] In the aftermath of Flight 447, many experts publicly warned about the increasing use of complex automated flight control systems to navigate the skies.[375]

Degradation of Manual Piloting Skills

The increasing reliance on modern automated systems can also a cause pilot's flight skills to decline, leaving a pilot unprepared for a crisis. As recently highlighted by the Congressional Research Service, "[r]esearch has shown that piloting skills associated with maneuvering aircraft using manual controls decline as a consequence of flying highly automated aircraft."[376] Indeed, FAA's Flight Deck Automation Working Group has acknowledged that pilots "sometimes rely too much on automated systems and may be reluctant to intervene" which can lead to deviations from intended flight paths and also erode their manual flying skills.[377] Notably, the number of hours pilots have logged may not offer a reliable indication of how equipped they are to manage automated flight systems during a crisis. For example, although the pilot on Air France Flight 447 had logged more than 346 flying hours in the six months preceding the crash, he had only logged approximately four hours of manual flight time over the same period.[378]

A 2005 study by the U.K Civil Aviation Authority Safety Regulation Group is instructive. It found that increased reliance on automation created a risk that flight crews may lack the skills required to "react appropriately to either failures in automation, programming errors or a loss of situational awareness."[379] The study analyzed aviation incidents in the prior three years, ultimately concluding that "there was much evidence to support the concern that crews were becoming dependent on flight deck automation."[380]

A 2010 study of pilots employed by U.S. carriers similarly found that, due in part to their reliance on automation, pilots tended to overestimate their ability to manually maneuver an aircraft when the automated flight system failed.[381] The study asked 30 pilots to perform basic maneuvers without the aid of automation and assessed the pilots' own perceptions of their piloting skills.[382] The study concluded that "although the pilots believed that they had retained a high degree of skill, all of the flight maneuvers were performed at levels below those required for U.S. airline transport pilot ("ATP") certification."[383]

RECOMMENDATIONS

The whistleblowers' collective concerns underscore the necessity of ongoing aircraft certification safety reform and oversight. To address specific safety concerns raised in this report, the Committee recommends that FAA, Congress, and other stakeholders take the following actions:

1. FAA needs to strengthen direct oversight of the ODA program, including direct approval of ODA unit members and assignment of safety advisors.

Under section 107 of the *Aircraft Certification, Safety, and Accountability Act*, beginning on January 1, 2022, FAA must directly approve ODA unit members, those industry engineers who act on behalf of the FAA, to assess and ensure aircraft designs comply with safety standards.

Similar to the former Designated Engineering Representative ("DER") system, section 107 of the *Aircraft Certification, Safety, and Accountability Act* also mandates that the FAA assign safety advisors who must directly oversee and communicate with ODA unit members at the manufacturers. This allows line engineers to flag safety issues and report instances of undue pressure to the FAA without interference.

The FAA issued two brief policy memorandums on October 15, 2021, announcing the new ODA oversight requirements. Now, FAA must take the necessary steps to fully implement these reforms by January 1, 2022. The first policy memorandum states that FAA must either approve or reject all ODA unit member selections made by the ODA holder, within 30 days of receiving notice of such a selection. All ODA procedures manuals must reflect this requirement. The second policy memorandum requires the FAA to assign safety advisors to the engineers and flight test ODA unit members at the Boeing, General Electric, and Pratt & Whitney ODAs. The FAA should report to Congress on this request and the implementation of these important reforms.

2. FAA must take measures to address undue pressure at the Boeing ODA and report to Congress on the status of any corrective action.

FAA has authority for enhanced oversight over the Boeing ODA under 49 U.S.C § 44702(d) and 14 C.F.R. Part 183, which authorizes the Administrator to rescind a delegation "at any time for any reason the Administrator considers appropriate." Based on this authority, Ian Won, Acting Manager of the BASOO, is currently investigating the Boeing ODA to assess the level of independence of ODA unit members and project administrators, and ability to transparently share information with FAA without fear of retaliation.

Based on BASOO investigation's findings, FAA should take steps to better supervise and control the Boeing ODA, address any issues of undue pressure, and report to Congress on the status of any corrective action.

Section 103 of the *Aircraft Certification, Safety, and Accountability Act* specifically calls on FAA to convene, within 30 days, an independent expert review panel to review the Boeing ODA's safety culture and capability to perform FAA-delegated functions. This expert panel is to be comprised of representatives of the FAA, National Aeronautics and Space Administration ("NASA"), labor unions, FAA line engineers and safety inspectors, and other stakeholders.

On November 3, 2021, Administrator Dickson reported to the Committee that the expert panel is now convening even as FAA missed the deadline of January 26, 2021 to convene the expert panel. Under section 103 of the *Aircraft Certification, Safety, and Accountability Act*, the panel is authorized to make recommendations that can serve as a basis for FAA to limit, suspend, or terminate the Boeing ODA's delegated authority. FAA must carefully review the panel's recommendations and report back to Congress on their implementation, but the agency should not delay in taking action.

The *Aircraft Certification, Safety, and Accountability Act* extended whistleblower protections, similar to those that were available to Federal workers and airline employees, to employees, contractors, and suppliers of aircraft manufacturers. This ensures that frontline workers and ODA unit members can voice safety concerns during the certification process without fear of retribution. FAA should report to Congress annually on any whistleblower complaints filed under the new law.

3. FAA must determine gaps in staffing levels and then ensure sufficient FAA technical and engineering capacity for safety oversight.

The FAA must ensure that the BASOO has a sufficient number of experienced engineers and technical specialists to adequately perform certification and oversight duties, commensurate with the extent of work being performed by Boeing. In other words, sufficient staffing at the BASOO is a condition precedent for thorough oversight of Boeing's ODA by FAA.

In 2015, OIG found that the BASOO only had 40 FAA employees and that the FAA did not know whether it had adequate staffing levels needed to meet workload requirements at the largest ODA oversight office In 2019, JATR issued a recommendation that FAA conduct a workforce review to identify proper staffing levels. The DOT OIG issued similar recommendations in 2015 and 2021.

Section 104 of the of the *Aircraft Certification, Safety, and Accountability Act* sought to address this problem by mandating that FAA examine and address any shortfalls in the agency's technical and engineering expertise to carry out its certification responsibilities. The FAA missed the September 22, 2021 deadline for this workforce review to be completed. This review is outstanding.

During the Committee hearing on November 3, 2021. Administrator Dickson confirmed in his testimony before the Committee on November 3, 2021, that the FAA has yet to conduct this workforce review – despite the Congressional mandate and timelines, and repeated findings from independent audits.

Chair Cantwell requested that Administrator Dickson provide a list of individuals that be involved in the enhanced direct oversight of ODA unit members and to ensure they have skill level to do the certification oversight work. FAA should report back immediately in response to this request.

The staffing levels at the BASOO must be adequate to meet the increased ODA safety responsibilities including having sufficient engineering capacity for the assignment of FAA safety advisors to the 1,500 ODA unit members at Boeing. FAA offices overseeing ODAs must be prepared to carry out direct approval and oversight of these unit members starting on January 1, 2022.

Once FAA has completed the review of workforce staffing levels mandated by section 104 of the *Aircraft Certification, Safety, and Accountability Act*, the FAA must then report additional needs to Congress for proper oversight of the design and manufacturing of aircraft.

4. FAA must review and verify all underlying human factors assumptions before delegating certification tasks related to safety critical design features, such as flight control systems.

Section 106 of the *Aircraft Certification, Safety, and Accountability Act* prohibits the FAA from delegating certification tasks related to safety critical design features, such as flight control systems, until the FAA has reviewed and verified all underlying human factors assumptions. Although this reform was effective immediately, amending 49 U.S.C. § 44702, the FAA waited until September 16, 2021 to issue a memorandum to all certification employees re-stating the law's requirements and reinforcing the need to validate underlying assumptions prior to delegating findings of safety critical systems compliance.

According to the information the FAA provided to the Committee, it appears this limitation has not been fully implemented. The FAA reported to the Committee that it is still conducting an analysis to ascertain when in the certification process it will identify critical design features and review and validate underlying assumptions related to human factors.

The Committee understands from FAA that the agency does not plan to update policy guidance on the limitation on delegation until 2023. This is not acceptable. The FAA should work to update this policy and guidance immediately and until then the FAA should take additional interim actions to implement the statutory limitation on delegation found in section 106 of the *Aircraft Certification, Safety, and Accountability Act*. This includes withholding delegation of certification tasks for safety critical design features until underlying assumptions related to human factors are validated.

5. FAA must require that manufacturers adopt formal safety management systems ("SMS") and implement root cause analysis followed by corrective action.

Under section 102 of the *Aircraft Certification, Safety, and Accountability Act*, FAA must issue regulations requiring holders of both a type certificate and a production certificate, such as aircraft and other aerospace industry manufacturers, to adopt SMS consistent with international standards and practices. The SMS must contain a confidential employee reporting system through which employees can report hazards and safety concerns, as well as a code of ethics emphasizing safety as the highest priority for a manufacturer's officers and employees. The FAA expects to issue a Notice of Proposed Rulemaking requiring SMS for manufacturers in 2022, but told the Committee that it will be "challenging" to meet the two-year deadline for issuing a final rule. Given that the FAA has previously launched such a rulemaking project in 2014, FAA should have acted prior to the section 102 mandate, especially in light of the 737 MAX accidents.[384]

Additionally, in October 20, 2021, DOT OIG found that the FAA's oversight of existing SMS programs is ineffective because the agency is not conducting comprehensive root cause analysis and verifying corrective actions under industry SMS programs, in this case, the SMS program of an air carrier. For example, in 171 of the 185 cases the DOT OIG sampled, FAA inspectors accepted root cause analyses done by air carriers that, in fact, *did not* identify the true root cause of the problem. Furthermore, the FAA closed some compliance actions *before* the air carrier actually implemented the corrective action.

As SMS is expanded to manufacturers and other industry actors, the FAA must improve the quality of its root cause analysis training and revise inspector guidance to ensure corrective actions are implemented before closing compliance action cases. But even effective implementation of SMS is only a supplement to ongoing regulatory compliance, not an alternative to it. The FAA's regulatory oversight should be conducted accordingly.

6. FAA must ensure integrated aircraft safety analysis that considers the cumulative effects of proposed design changes to the aircraft, human factors issues, and impacts on training for pilots and maintenance personnel.

The FAA should continue to update the Changed Product Rule in conjunction with international partners, as required by sections 115 and 117 of the *Aircraft Certification, Safety, and Accountability Act*. Together, sections 115 and 117 mandate the FAA to conduct a rulemaking to require proposals for new aircraft designs (type certificates) and variants of existing aircraft designs (amended type certificates) to undergo an integrated system safety analysis. This analysis must account for the cumulative effects of proposed design changes to the aircraft, human factors issues, and impacts on training for pilots and maintenance personnel.

Section 117 also requires the FAA to exercise leadership within the International Civil Aviation Organization ("ICAO") and among other civil aviation regulators to advocate for the adoption of an amended changed product rule on a global basis, consistent with ICAO standards.

In the interim, the FAA should mandate that applicants for an amended type certificate for a transport airplane perform a system safety assessment with respect to each proposed design change that is significant, considering the airplane-level effects of individual failures and realistic pilot response times. The FAA must review each system safety assessment for sufficiency and adequate consideration of the airplane-level effects of individual failures and realistic pilot response times.

7. FAA should complete its annual safety culture survey, as determined by its frontline safety staff.

Section 132 of the *Aircraft Certification, Safety, and Accountability Act* requires the Administrator to conduct an annual safety culture assessment, through fiscal year 2031. It must include surveying all employees in the FAA's Aviation Safety organization ("AVS") to determine their opinions regarding AVS' safety culture and implementation of any voluntary safety reporting program, such as that required by section 113 of the *Aircraft Certification, Safety, and Accountability Act*.

Under questioning from the Committee on November 3, 2021, Mr. Dickson admitted that FAA has yet to conduct the annual safety culture survey for 2021. FAA must immediately execute this mandate. To determine if further action is required, Congress should carefully review the results of this safety survey and the effectiveness of the FAA's new voluntary confidential safety reporting program, as mandated by the *Aircraft Certification, Safety, and Accountability Act*.

8. FAA should build greater accountability into the aircraft design process to ensure compliance with airworthiness standards and immediate corrective action for non-compliant designs.

In his testimony before the Committee, Administrator Dickson expressly agreed that when applicants are submitting design data to the FAA for a finding of compliance, they should certify in writing to the FAA that the submitted data complies with all the applicable airworthiness standards. He also committed that if the design does not comply with the applicable airworthiness standards, the applicant should bring the design into compliance *before* the FAA certifies the aircraft.

The FAA should ensure that this attestation by the applicant is occurring and take measures to issue guidance for industry and keep records to demonstrate compliance. The FAA should enforce section 120 of the *Aircraft Certification, Safety, and Accountability Act*, which requires aircraft manufacturers to present to the FAA and deliver aircraft to customers that conform with an approved type design — the configuration that the FAA certified as safe — or be subject to a $1 million fine per aircraft.

9. FAA must strengthen its oversight over the production process to address scheduling pressures and problems in the supply chain.

Whistleblower claims, such as those made by Dr. Bickeboeller, regarding problems with Boeing's 787 supply chain have proven prescient as the aircraft continues to suffer from quality issues in its components and parts. With the 737 MAX production likely to ramp up in the near future, issues of scheduling pressure and production problems, as described by Mr. Pierson, could arise again.

Fostering an environment where undue pressure to maintain production schedules persists, and causes supply chain nonconformities to not be properly addressed, is unacceptable. To address this, the FAA should review its inspector workforce and work plan, including through ongoing surveillance, to determine whether FAA has sufficient staff and processes in place to address production problems from scheduling pressure and in the supply chain. Given the global reach of supply chains involved in aircraft manufacturing, surveillance plans should include inspection of overseas production facilities operating under FAA certificates. In strengthening safety oversight, FAA should coordinate with civil aviation authorities where foreign supply chain companies are based.

10. FAA must build up its technical capacity and capability to effectively evaluate and certify increasingly complex flight systems technology.

If the 737 MAX had been certified properly by the FAA, fully in accordance with FAA regulations, Curtis Ewbank asserted that the aircraft would have had the "most up-to-date understanding of system design and critical human-machine interfaces" to mitigate safety risks. In response, section 124 of the *Aircraft Certification, Safety, and Accountability Act* directs the FAA to conduct an evaluation of tools and methods that support the better integration of human factors and system safety assessments of aircraft flight deck and flight control systems into the FAA's certification process. Under section 124, FAA is also required to develop a human factors education program for the FAA employees that teaches about the effects of modern flight deck systems on human performance and new approaches for better integration of human factors into aircraft design and certification.

Additionally, Section 112 of the *Aircraft Certification, Safety, and Accountability Act* mandates that FAA establish new continuing workforce education and training programs that will keep FAA certification staff current on the latest knowledge regarding the intersection of human factors and flight automation/modern flight deck systems.

A FAA Center of Excellence expansion is also taking place to promote and facilitate research collaborations around automation and technological advancements in human systems integration and aircraft interfaces. This is required under section 127 of the *Aircraft Certification, Safety, and Accountability Act* and stakeholders included in this effort include the FAA, the aircraft and airline industry, and technical and higher education institutions.

The Committee understands FAA is taking steps to implement these reforms and encourages FAA to continue leveraging their partnerships with industry, professional associations, and academia to fill technical capacity and capability gaps as quickly as possible in the meantime.

11. Congress should consider programs to address staffing shortages in aerospace to prevent the loss of engineering experience and knowledge necessary to develop complex and innovative aircraft systems.

According to the Aerospace Industries Association, the civil aviation sector's workforce shrunk by 87,000 jobs in 2020, due in large part to the COVID-19 pandemic.

To stem this trend, Chair Maria Cantwell led the effort to include the Aviation Manufacturing Jobs Protection ("AMJP") program in the American Rescue Plan, which provides payroll grants to manufacturers and supply chain companies to protect, preserve and rehire their skilled workforce. To date, the AMJP has awarded approximately $666 million in funds to 472 businesses in the supply chain, preserving almost 31,000 jobs across 41 states and Puerto Rico.

The DOT is allowing new applicants to apply for AMJP funds. Final applications will be due on Monday, December 13, 2021. The Employee Retention Tax Credit ("ERTC") program is no longer a constraint on AMJP awards. Manufacturer and supply chain companies seeking to preserve their talented workforce should apply for AMJP assistance.

Congress should also consider extension of the AMJP past the current March 2022 end date, or initiate other programs to address staffing shortages at aviation manufacturers and prevent the loss of engineering experience and knowledge necessary to develop complex and innovative aircraft systems. This critical workforce, from machinists to engineers, is the backbone of America's global leadership in aviation.

With respect to FAA, Congress should fully fund programs to increase the FAA technical workforce and expertise. This includes funding for FAA's continuing education and training programs. FAA certification staff must stay current on the latest knowledge regarding the intersection of human factors and flight automation and modern flight deck systems.

WHISTLEBLOWERS

Investigative Process

Whistleblowers perform a critical public service by exposing wrongdoing in government and the private sector. Here, seven individuals—all of whom have agreed to be identified in this report—contacted the Committee to convey their experiences, concerns, and recommendations regarding the aircraft safety and certification environment at the FAA and within the industry. The seven individuals have a diverse range of experience in the U.S. aircraft certification ecosystem, with technical expertise from the FAA, engineering experience at Boeing and GE, and other direct knowledge of aviation production, management, safety, and compliance processes.

The Committee staff interviewed these whistleblowers multiple times over the course of numerous months, and they provided the Committee with written statements and reports detailing their concerns. The Committee appreciates the whistleblowers' willingness to engage in this process and contribute to this report.

The Committee attempted to honor these whistleblowers by addressing many of their concerns when drafting the *Aircraft Certification, Safety, and Accountability Act.* Whistleblower protections have long existed for Federal employees,[385] and have been improved and strengthened significantly over the past several decades.[386] In 2000, whistleblower protections were also codified for airline employees.[387] Last year, the *Aircraft Certification, Safety, and Accountability Act*, took the important step of extending these same kinds of protections to employees, contractors, and suppliers of aircraft manufacturers.[388]

Whistleblowers

Dr. Martin Bickeboeller

Dr. Bickeboeller currently works at Boeing as a Technical Fellow. He started working there in 1987 and became one of the first employees to be selected to work on the 787 development program in the early 2000s. Dr. Bickeboeller served as the Chief Process Architect of the program, and in 2004, Boeing promoted him to the Technical Fellow position, a high-level engineering role charged with setting technical direction for the company and resolving issues that arise when it creates new products. He served as the Technical Fellow for Configuration Management compliance for 787 Dreamliner suppliers from 2008

to 2011. Dr. Bickeboeller filed complaints with Boeing Ethics and quality control personnel, and with higher levels of Boeing management such as the Chief Technology Officer and the Chief Engineer. The Committee spoke with Dr. Bickeboeller on numerous occasions, beginning on January 8, 2020. Dr. Bickeboeller also submitted documentation to the Committee of a complaint he filed with FAA on October 25, 2021 to seek enforcement action against Boeing.

G. Michael Collins

Mr. Collins is a retired aerospace engineer who worked at the FAA for more than 29 years specializing in aircraft propulsion. Mr. Collins also spent five years at Boeing and has relevant experience in other industries where safety processes are critical, such as nuclear and non-nuclear power plant design. Mr. Collins first met with the Committee in January 2020 and has since spoken with staff numerous times. In addition, Mr. Collins submitted a written statement to the Committee on August 16, 2021.

Mike Dostert

Mr. Dostert is a current aerospace engineer at the FAA. On July 7, 2020, he wrote a letter to the Department of Transportation's Office of the Inspector General detailing his concerns about a "breakdown" of FAA's aircraft certification process, which is run through FAA's Aircraft Certification Service ("AIR"). The Committee has been in communication with Mr. Dostert since at least January 2020. Mr. Dostert later forwarded that letter to the Committee, and Committee staff spoke with him on several occasions.

Curtis Ewbank

Mr. Ewbank is a former aerospace engineer at Boeing. He worked on both the 737 MAX and 777X programs, specializing in integrating flight deck system design with flight crew operations. Following the Lion Air flight 610 crash, he drafted an ethics complaint describing his ethical and safety concerns relating to Boeing's corporate culture and the 737 MAX design and certification process. Mr. Ewbank submitted the ethics complaint to investigators in Boeing's internal ethics department on April 29, 2019. He was on paid leave while his ethics complaint was evaluated prior to his departure from the company. Mr. Ewbank sent various memoranda to the Committee, including the ethics complaint and a June 2020 letter. The Committee has spoken with Mr. Ewbank numerous times since.

Joe Jacobsen

Mr. Jacobsen is a former FAA safety and aerospace engineer who retired in March 2021. Before joining the FAA, he spent 11 years at Boeing as an aerodynamicist on the 767 and 777 programs. Mr. Jacobsen shared a letter with the Committee, dated February 8, 2021, from Mr. Jacobsen to Michael Stumo and Nadia Milleron, parents of Samya Rose Stumo, a 24-year-old American who died on Ethiopian Airlines Flight 302. In the letter, he explained what he thinks went wrong during the 737 MAX certification process. Mr. Jacobsen also submitted to the Committee his analysis on original design non-compliances associated with the 737 MAX. The Committee staff has spoken with him on numerous occasions.

Richard Kucera

Mr. Kucera, a former, longtime engineer with GE Aviation, led a division of GE's Organization Designation Authorization ("ODA") unit responsible for supporting the issuance of production certifications or approvals for GE engines on behalf of the FAA. On October 6, 2021, Mr. Kucera wrote a letter to the Committee describing experiences of undue pressure and duties in conflict with his FAA responsibilities as the lead on GE's production certificate ODA, particularly with regard to the GE9X engine. These experiences all occurred after the *Aircraft Certification, Safety, and Accountability Act* became law. The Committee spoke with Mr. Kucera several times over the course of the last few months.

Ed Pierson

Mr. Pierson worked for Boeing for 10 years, including as a senior manager, before retiring in 2018. He oversaw production support for the final assembly of the 737 series, wing components, and the U.S. Navy's P-8 Poseidon aircraft. He also served as a Senior Manager for Boeing's Test and Evaluation division that is responsible for testing flight operations of newly manufactured aircraft. Previously, he spent 30 years in the United States Navy as a Naval Flight Officer before retiring. On January 20, 2021 he posted a report to his website with his analysis of the two 737 MAX investigations. The report included his observations of working conditions at Boeing's 737 Factory in Renton, Washington. Mr. Pierson updated this report on May 10, 2021 after Boeing and the FAA announced newly discovered electrical bonding and grounding problems, and later shared it with Committee staff, who interviewed him several times.

COMMITTEE'S SAFETY WORK

Committee Focus on Aviation Safety

This report is part of the Committee's continued investigation of the design and certification of the 737 MAX, including FAA safety oversight practices.

Under both Democratic and Republican leadership, the Committee has held a series of oversight hearings related to FAA safety oversight and the 737 MAX, involving a wide-range of witnesses including Federal safety regulators, national and international investigators, leadership of aviation manufacturers, and family members of the victims:

- The State of Airline Safety: Federal Oversight of Commercial Aviation, March 27, 2019;[389]
- Nomination Hearing for Administrator of Federal Aviation Administration, May 15, 2019;[390]
- Aviation Safety and the Future of Boeing's 737 MAX, October 29, 2019;[391] and
- Examining the Federal Aviation Administration's Oversight of Aircraft Certification, June 20, 2020.[392]
- Implementation of Aviation Safety Reform, November 3, 2021.[393]

Based on its oversight and investigative work, the Committee drafted bipartisan legislation, S.3969*,* the *Aircraft Safety and Certification Reform Act of 2020*, which was introduced by Senators Cantwell and Wicker on June 16, 2020. This legislation built upon prior legislation Chair Cantwell introduced. This includes the *Aviation Automation and Human Factors Safety Act of 2019*, a bill to implement aviation safety recommendations from the National Transportation Safety Board, the Department of Transportation's Office of the Inspector General, and the International Civil Aviation Organization ("ICAO"). These recommendations would seek to address challenges related to increased automation in commercial aircraft cockpits, as well as how pilots respond to flight deck alerts and un-commanded flight control inputs. Senator Cantwell also introduced bipartisan legislation, the *National Air Grant Fellowship Program Act of 2020*, to create one-year paid aerospace policy fellowship roles for graduate and post-graduate

students in Congress, at the FAA, and in other Federal agencies. The goal of this bill was to help build a pool of talent conversant in emerging technologies for the FAA and Congress to draw from as they make policy in the aviation sector. In addition, Senator Cantwell led bipartisan legislation, the *Foreign Civil Aviation Authority Assistance Act of 2020*, to authorize the FAA to work with other countries to strengthen pilot training standards and enable ICAO to further enhance worldwide aviation safety and training standards.

On December 20, 2019, the Republican staff of the Committee issued an investigative report on "Aviation Safety Oversight," which detailed a number of significant lapses in aviation safety oversight and failed leadership in the FAA, including, but not limited to, certification of the 737 MAX.[394]

The Committee favorably reported S.3969, as amended, on November 18, 2020. Pursuant to bipartisan negotiations with the House Transportation and Infrastructure Committee, S. 3969 was modified and included in the *Consolidated Appropriations Act, 2021* (P.L. 116-260) as Division V. The final version of the *Aircraft Certification, Safety, and Accountability Act*, signed into law on December 27, 2020, incorporated key Committee priorities and reflected safety reforms resulting from nearly two years of investigative and oversight efforts.

Following the enactment of *Aircraft Certification, Safety, and Accountability Act*, the Committee has continued to conduct oversight of FAA's implementation of the legislation through formal briefings from the agency and continuous dialogue with FAA staff. In addition, during confirmation hearings for Department of Transportation leadership, including for Secretary Pete Buttigieg, Chair Cantwell has requested and received a commitment for implementation of the *Aircraft Certification, Safety, and Accountability Act* and improving the safety culture of the FAA[395].

Following the passage of the *Aircraft Certification, Safety, and Accountability Act,* Chair Cantwell said: "I want to thank all of the families who helped us in communicating why these safety reforms are important … and to let them know that even though we're putting a big down payment on safety reforms in the United States Congress by passing this legislation, this process does not stop with the passage of this legislation."[396] This report is representative of this obligation and dedication to continuous aviation safety reform.

Other Investigations

While this report is not intended to duplicate extensive and well-documented investigations of Lion Air Flight 610 and Ethiopian Airlines Flight 302, the Committee acknowledges the work of other investigative bodies, including, but not limited to:

- National Transportation Safety Bureau ("NTSB"): Following a preliminary investigation, on September 19, 2019, the NTSB issued findings and recommendations to address assumptions about pilot recognition and response to failure conditions used during the design certification process as well as diagnostic tools to improve the prioritization and clarity of failure indications presented to pilots.[397]

- Joint Aviation Technical Review ("JATR"): Chaired by former National Transportation Safety Board Chairman Christopher A. Hart, the JATR was comprised of technical safety experts from nine civil aviation authorities worldwide, as well as the FAA and NASA.[398] On October 11, 2019, the JATR issued findings and recommendations concerning the design, certification, regulations, compliance, training, and Organization Designation Authorization activities associated with the 737 MAX.[399]

- National Transportation Safety Committee of Indonesia (known by its Indonesian acronym KNKT): On October 24, 2019, the KNKT, Indonesia's accident investigation body, completed its investigation of the causes of Lion Air Flight 610.[400] The KNKT cited the flawed design of the Maneuvering Characteristics Augmentation System ("MCAS") as the chief cause, but also found that FAA did not provide sufficient oversight over the certification process.[401]

- Special Committee to Review FAA's Aircraft Certification Process: Formed within the structure of the Safety Oversight and Certification Advisory Committee ("SOCAC"), created by Section 202 of the FAA Reauthorization Act of 2018, DOT tasked the Special Committee to review the certification process, evaluate potential enhancements, and issue recommendations.[402] On January 16, 2020, the Special Committee issued its report on the 737 MAX certification.[403]

- House Transportation and Infrastructure Committee: On September 16, 2020 the U.S. House T&I Committee concluded its investigation and issued a report on the design, development, and certification of the 737 MAX aircraft.[404] The report documented a series of faulty technical

assumptions by Boeing's engineers, a lack of transparency on the part of Boeing's management, and grossly insufficient oversight by the FAA.[405]

- Department of Justice ("DOJ"): On January 7, 2021, Boeing entered into an agreement with the DOJ to resolve a criminal charge related to a conspiracy to defraud the FAA in connection with the FAA evaluation of Boeing's 737 MAX airplane.[406] Boeing agreed to pay a total criminal monetary amount over $2.5 billion.[407] DOJ found that Boeing willfully conspired and agreed with others to defraud the FAA by lying about MCAS, including for purposes of the 737 MAX Flight Standardization Board Report and the 737 MAX differences-training determination.[408]

- Department of Transportation Office of Inspector General ("DOT OIG"): On June 29, 2020, DOT OIG issued its first report providing a timeline of the FAA certification process leading to the approval of the 737 MAX 8, and the subsequent FAA and Boeing activities between the October 2018 Lion Air and March 2019 Ethiopian Air crashes.[409] On February 23, 2021, DOT OIG issued another report detailing weaknesses in FAA's processes for certifying the MAX and recommendations for FAA to improve its oversight of the ODA program.[410] On April 20, 2021, DOT OIG initiated an audit of FAA's oversight of the MAX's return to service.[411]

List of Abbreviated Terms

ACSAA	Aircraft Certification, Safety, and Accountability Act
AC	Advisory Circular
AD	Airworthiness Directive
AIR	Aircraft Certification Service
AIA	Aerospace Industries Association
AMJP	Aviation Manufacturing Jobs Protection program
AOA	Angle of Attack
ARC	Aviation Rulemaking Committee
ASA JSAT	Airplane State of Awareness Joint Safety Analysis Team
ATP	Airline Transport Pilot
AVS	Aviation Safety Organization at the Federal Aviation Administration
BASOO	Boeing Aviation Safety Oversight Office
BCA	Boeing Commercial Airplanes
BPSM	Boeing Problem Solving Model
CAST	Commercial Aviation Safety Team
CCS	Common Core System
CDO	Certificated Design Organization
CDPO	Certified Design and Production
COE TTHP	FAA Center of Excellence for Technical Training and Human Performance
COS	Continued Operational Safety
DAR	Designated Airworthiness Representative
DAS	Designated Alteration Station
DERs	Designated Engineering Representatives
DOA	Design Organisation Approval (EASA)
DOA	Delegation Option Authorization (FAA)
DOJ	Department of Justice
DOT OIG	Department of Transportation Office of the Inspector General
DER	Designated Engineering Representatives
EASA	European Union Aviation Safety Agency
EAD	Emergency Airworthiness Directive
E-BOM	Engineering Bill of Materials
EICAS	Engine Indicating and Crew Alerting System
ERTC	Employee Retention Tax Credit
E-UMs	Engineering Unit Members
FAA	Federal Aviation Administration
FARs	Federal Aviation Regulations
FCC	Flight control computer
GAMA	General Aviation Manufacturer’s Association
GAO	Government Accountability Office

GE	General Electric Company
GFI	Ground Fault Interrupter
ICAO	International Civil Aviation Organization
JATR	Joint Aviation Technical Review
KNKT	National Transportation Safety Committee of Indonesia
M-BOM	Manufacturing Bill of Materials
MCAS	Maneuvering Characteristics Augmentation System
MHI	Mitsubishi Heavy Industries, Ltd.
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
ODA	Organization Designation Authorization
ODAR	Organizational Designated Airworthiness Representative
SACO	Seattle Airplane Certification Office
SAW	Safety and Airworthiness
SERs	Supplier Evaluation Records
SFAR	Special Federal Aviation Regulation
SME	Subject Matter Expert
SMS	Safety Management Systems
SOCAC	Safety Oversight and Certification Advisory Committee
TAB	Technical Advisory Board
TIA	Type Inspection Authorization

Appendix

- Aircraft Certification, Safety, and Accountability Act, Section-by-Section (summary).

- Dr. Martin Bickeboeller, “Subject: Complaint filed for the purpose of seeking enforcement action according to Code of Federal Regulations, Title 14, Part 13, section 13.5” (sent to FAA), October 25, 2021.

- G. Michael Collins, Written Statement to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, August 16, 2021.

- Michael Dostert, Letter to Department of Transportation Office of the Inspector General: “Aircraft Certification Service Considerations for Addressing Shortfalls,” July 7, 2020.

- Curtis Ewbank, Letter to U.S. Senate Commerce, Science, and Transportation Committee, June 5, 2020.

- Curtis Ewbank, 737 MAX Ethics Statement, June 30, 2020.

- Joe Jacobsen, Letter to Stumo Family, February 8, 2021.

- Joe Jacobsen, “Original 737 Max Design Non-compliances with 14 CFR Part 25,” September 3, 2021.

- Richard J. Kucera, Letter to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, “Problematic FAA Delegation in Large FAA Organization Designation Authorizations (ODAs),” November 2, 2021.

- Richard J. Kucera, GE Aviation Coaching Plan, March 19, 2021.

- Ed Pierson, Letter to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, October 30, 2021.

- Ian Won, “FAA Letter to Boeing: Assessment results regarding Organization Designation Authorization (ODA) Unit Member (UM) Independence,” August 19, 2021.

- Ian Won, Letter to Tom Galantowicz, “Boeing Model 777-9 Type Inspection Authorization (TIA) Readiness,” May 13, 2021.

[1] Public Law 116-260, Division V. *See* appendix for a section-by-section summary of the law.
[2] A production certificate attests that a product complies with the FAA-approved type certificate, *i.e.*, the product complies with the approved design. *See* Federal Aviation Administration, "Product Certification," last visited December 9, 2021, *available at* https://www.faa.gov/aircraft/air_cert/production_approvals/prod_cert/. To achieve a production certificate, the applicants must demonstrate compliance through conformity inspections. *Id*.
[3] GE Aviation disputed claims made by Mr. Kucera. The company's correspondence is on file with the Committee.
[4] Richard J. Kucera, Letter to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, "Problematic FAA Delegation in Large FAA Organization Designation Authorizations (ODAs)," November 2, 2021 (see Appendix, hereinafter "Kucera letter"), p. 5.
[5] *Id.* at p. 4.
[6] Richard Kucera GE Aviation Coaching Plan, March 19, 2021 (see Appendix, hereinafter "Kucera Coaching Plan"), p. 1. Mr. Kucera also shared with the Committee a May 13, 2021 version of the coaching plan, which featured different termination language. The May 13 version of the plan is on file with the Committee.
[7] Kucera letter at p. 4.
[8] *Id.*
[9] *Id*. at p. 3.
[10] *Id.*
[11] *Id.*
[12] Kucera Coaching Plan at p. 1.
[13] *Id.* at p. 2.
[14] Kucera letter at p. 4.
[15] *Id.*
[16] *Id.*
[17] *Id.* at p. 1
[18] *Id.* at p. 6.
[19] *Id.* at p. 6. Mr. Kucera explained that although the Catalyst engine was developed in Prague under an EASA Production Organisation Approval, its type certificate and associated conformity activities were managed on behalf of the FAA by GE Aviation's ODA. *Id.*
[20] *Id.*
[21] *Id.* at p. 7.
[22] *Id.* at p. 8.
[23] Dr. Martin Bickeboeller confidential interview with U.S. Senate Commerce, Science, and Transportation Committee Democratic Staff (summary), January 8, 2020 (hereinafter "Bickeboeller interview").
[24] *Id.*
[25] *Id.*
[26] Dominic Gates, "Boeing 787's problems blamed on outsourcing, lack of oversight," *The Seattle Times*, February 2, 2013, *available at* https://seattletimes.com/business/boeing-787rsquos-problems-blamed-on-outsourcing-lack-of-oversight/.
[27] *Id*; Federal Aviation Administration, "Formal Compliant Docket No. 2014-2: Final Response to Configuration Management Complaint Regarding a Boeing Supplier in Italy," February 16, 2016 (FAA response to a Bickeboeller whistleblower claim) (hereinafter "FAA Response to Complaint Docket No. 2014-2"), p. 13, *available at* https://www.faa.gov/foia/electronic_reading_room/boeing_reading_room/media/ewb16512.pdf.
[28] Bickeboeller interview at p. 17, 20-23.
[29] *Id.* at p. 1
[30] FAA Response to Complaint Docket No.2014-2 at p. 3.
[31] Dr. Martin Bickeboeller, "Subject: Complaint filed for the purpose of seeking enforcement action according to Code of Federal Regulations, Title 14, Part 13, Section 13.5," (sent to FAA) October 25, 2021 (see Appendix, hereinafter "Bickeboeller complaint to FAA"), p. 6.

[32] Bickeboeller interview at p. 2.
[33] *Id.* at p. 2.
[34] *Id.*
[35] *Id.* at p. 7.
[36] *Id.* at p. 2.
[37] *Id.* at p. 1.
[38] *Id.*
[39] *Id.* at p. 3.
[40] FAA Response to Complaint Docket No. 2014-2 at p.2.
[41] Bickeboeller interview at p. 3.
[42] Bickeboeller complaint to FAA at p. 3.
[43] FAA Response to Complaint Docket No.2014-2 at p.3.
[44] Bickeboeller complaint to FAA at p. 92.
[45] *Id.* at p. 2.
[46] By example, Boeing halted production of defective fuselage sections produced by Alenia Aeronautica (now Leonardo) for the Boeing 787 in 2009. *See* Christopher Drew, "Boeing Halts Production of Flawed Dreamliner Part," *The New York Times*, August 14, 2009, *available at*: https://www.nytimes.com/2009/08/15/business/15boeing.html.
[47] By example, Boeing identified defects in 2014, produced by Mitsubishi Heavy Industries, which resulted in cracked wings on about 40 Boeing 787 aircraft that were scheduled to be delivered to customers. *See* W.J. Hennigan, "Boeing inspecting Dreamliner wings for cracks; possible delivery delays," *Los Angeles Times*, March 7, 2014, *available at* https://www.latimes.com/business/la-fi-mo-boeing-dreamliner-wing-cracks-20140307-story.html.
[48] Dominic Gates, "FAA memo reveals more Boeing 787 manufacturing defects, including contamination of carbon fiber composites," *The Seattle Times*, November 19, 2021 (hereinafter "Gates article November 19, 2021"), *available at* https://www.seattletimes.com/business/boeing-aerospace/faa-memo-reveals-more-boeing-787-manufacturing-defects-including-contamination-of-carbon-fiber-composites/.
[49] *Id*.
[50] *Id.*
[51] Andrew Tangel, "Boeing Dreamliner Defects Bog Down Production," *The Wall Street Journal*, November 19, 2021 (hereinafter "Tangel article"), *available at:* https://wsj.com/articles/boeing-dreamliner-defects-bog-down-pdorduction-11637335163.
[52] *Id.*
[53] *Id*.
[54] Gates article November 19, 2021.
[55] Tangel article.
[56] Gates article November 19, 2021.
[57] Ed Pierson, Letter to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, October 30, 2021 (see Appendix), p. 9.
[58] *Id.*
[59] *Id.*
[60] *Id.* at p. 11.
[61] Ian Won, "FAA Letter to Boeing: Assessment results regarding Organization Designation Authorization (ODA) Unit Member (UM) Independence," August 19, 2021 (see Appendix, hereinafter "Won letter to Boeing"), p. 1-2.
[62] *Id.*
[63] *Id.* These respondents did not contact the Committee.
[64] *Id.*
[65] Won letter to Boeing at p. 2.
[66] *Id.*
[67] *Id* at p. 2.
[68] *Id* at p. 1.
[69] *Id.*at p. 3.
[70] *Id.*
[71] *Id.* at p. 2.

[72] *Id.*
[73] Joint Authorities Technical Review (JATR), "Boeing 737 MAX Flight Control System: Observations, Findings, and Recommendations," October 11, 2019 (hereinafter "JATR Report"), VIII, *available at* https://www.faa.gov/sites/faa.gov/files/2021-08/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.
[74] Curtis Ewbank, 737 MAX Ethics Statement, June 30, 2020 (see Appendix, hereinafter "Ewbank Ethics Statement"), p. 1.
[75] *Id.* at p. 1.
[76] *Id.*
[77] *See Id.*
[78] *Id.*
[79] *Id.* at p. 5.
[80] *Id.* at p. 4.
[81] The Commercial Aviation Safety Team (CAST), "Goal, Mission, Vision," last visited December 9, 2021, *available at* https://www.cast-safety.org/apex/f?p=102:1:9755595804544::NO::P1_X:mission.
[82] Ewbank Ethics Statement at p. 4.
[83] ASA JSAT performs in-depth analysis of aviation safety issues and identifies and evaluates risk mitigation factors to address such issues. *See* Federal Aviation Administration, "Commercial Aviation Safety Team," September 3, 2021, available at: https://www.faa.gov/newsroom/commercial-aviation-safety-team.
[84] Ewbank Ethics Statement at p. 5.
[85] *See* Federal Aviation Administration, "Summary of the FAA's Review of the Boeing 737 MAX," November 18, 2020, *available at* https://www.faa.gov/foia/electronic_reading_room/boeing_reading_room/media/737_RTS_Summary.pdf, p. 76.
[86] Ewbank Ethics Statement at p. 5.
[87] *Id.*
[88] *Id.*
[89] *Id.*
[90] *Id.*
[91] *Id.*
[92] *Id.*
[93] *Id.*
[94] *Id.*
[95] *Id.*
[96] *Id.*
[97] *Id.* at p. 6.
[98] *Id.*
[99] *Id.*
[100] Bureau of Aircraft Incident Archives, "Crash of a Boeing 757-225 off Puerto Plata: 189 Killed," last visited December 9, 2021, available at https://baaa-acro.com/crash/crash-boeing-757-225-puerto-plata-189-killed.
[101] Ewbank Ethics Statement at p. 6.
[102] *Id.* at p. 7.
[103] *Id.*
[104] Curtis Ewbank, Letter to U.S. Senate Commerce, Science, and Transportation Committee, June 5, 2020 (see Appendix, hereinafter "Ewbank letter").
[105] Ewbank Ethics Statement at p. 2.
[106] *Id.*
[107] *Id.*
[108] *Id.*
[109] *Id.*
[110] *Id.*
[111] Ewbank letter at p. 3.
[112] Ewbank Ethics Statement at p. 3.
[113] Ewbank letter at p. 4.

[114] *Id.* at p. 5.
[115] *See* G. Michael Collins, Written Statement to Chair Maria Cantwell, U.S. Senate Commerce, Science, and Transportation Committee, August 16, 2021 (see Appendix, hereinafter "Collins statement").
[116] *Id.* at p. 3.
[117] *Id.* at p. 4.
[118] *Id.* at p. 9.
[119] *Id.* at p. 5
[120] *Id.*
[121] *Id.* at p. 6
[122] Nat'l Transp. Safety Board, "Aircraft Incident Report: Auxiliary Power Unit Battery Fire Japan Airlines Boeing 787-8, JA829J, Boston, Massachusetts," January 7, 2013 (hereinafter "NTSB 787 Report") *available at* https://www.ntsb.gov/investigations/AccidentReports/Reports/AIR1401.pdf, p. viii.
[123] Collins statement at p. 5.
[124] *Id.*
[125] *Id.* at p. 6.
[126] *Id.*
[127] 66 FR 23085, Federal Aviation Administration, "Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements," May 7, 2001, *available at* https://www.federalregister.gov/documents/2001/05/07/01-10129/transport-airplane-fuel-tank-system-design-review-flammability-reduction-and-maintenance-and.
[128] Collins statement at p. 2
[129] *Id.*
[130] *Id.*
[131] *Id.*
[132] *Id.*
[133] *Id.* at pp. 1-2.
[134] Joe Jacobsen, Letter to Stumo Family, February 8, 2021 (see Appendix, hereinafter "Jacobsen letter"), p. 2.
[135] *Id.*
[136] *Id.*
[137] *Id.* at p. 2.
[138] *Id.*
[139] *Id.*
[140] *Id.*
[141] *Id.* at p. 1.
[142] *Id.* at p. 2.
[143] Mike Dostert, "Aircraft Certification Service Considerations for Addressing Shortfalls," July 7, 2020 (see Appendix, hereinafter "Dostert letter").
[144] *Id.* at p. 4.
[145] "Safety Culture Assessment Report," Federal Aviation Administration (FAA) Aviation Safety Organization (AVS), prepared by The MITRE Corporation, February 28, 2020 (on file with the Committee).
[146] *Id.*
[147] *Id.*
[148] *Id.*
[149] Dept. of Transp. Office of Inspector General, "Timeline of Activities Leading to the Certification of the Boeing 737 MAX 8 Aircraft and Actions Taken After the October 2018 Lion Air Accident," AV2020037, June 29, 2020, (hereinafter "2020 DOT OIG 737 MAX certification report"), *available at* https://www.oig.dot.gov/sites/default/files/FAA%20Oversight%20of%20Boeing%20737%20MAX%20Certification%20Timeline%20Final%20Report.pdf.
[150] *Id.* at p. 4.
[151] *Id.* at p. 27.
[152] JATR report at p. 50.
[153] *Id.*

[154] Federal Aviation Administration, PowerPoint "Boeing Aviation Safety Oversight Office (BASOO) Update, Presented to NATCA," June 15, 2010 (on file with the Committee).
[155] Dostert letter at p. 5.
[156] *Id.* at p. 11.
[157] Dept. of Transp. Office of Inspector General, "Audit Report: Weaknesses in FAA's Certification and Delegation Processes Hindered Its Oversight of the 737 MAX, AV2021020," February 21, 2021 (hereinafter "2021 DOT OIG 737 MAX audit report"), *available a*t https://www.oig.dot.gov/sites/default/files/FAA%20Certification%20of%20737%20MAX%20Boeing%20II%20Final%20Report%5E2-23-2021.pdf, p. 4.
[158] *Id.* at pp. 9, 30.
[159] *Id.* at p. 30.
[160] JATR report at p. 27. It is not clear whether the JATR report included technical project managers in this figure.
[161] *Id.*
[162] *Id.*
[163] *Id.*
[164] *Id.* at IX.
[165] 2021 DOT OIG 737 MAX audit report at p. 30.
[166] *Id*.
[167] *Id.*
[168] Ewbank letter at p. 2.
[169] *Id.*
[170] Ewbank Ethics Statement at p. 7.
[171] *Id.* at p. 4.
[172] *Id.* at p. 2.
[173] *Id.*
[174] *Id.*
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[176] *Id.* at pp. 4-5.
[177] Joe Jacobsen, "Original 737 Max Design Non-compliances with 14 CFR Part 25," September 3, 2021 (see Appendix, hereinafter "Jacobsen report").
[178] Jacobsen letter at p. 1.
[179] *Id.*
[180] *Id.* at p. 1
[181] *Id.*
[182] *Id.*
[183] *Id.*
[184] *Id.*
[185] *See* 14 CFR § 21.101(a).
[186] *See* 14 CFR § 21.101(b)(1).
[187] Ewbank Ethics Statement at p. 3.
[188] *Id.*
[189] *Id.* at p. 2.
[190] *Id.*
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[192] *Id.* at p. 3.
[193] *Id.* at p. 5.
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[195] *See* 14 CFR § 21.101.
[196] Jacobsen letter at p. 6.
[197] *Id.* at p. 5.
[198] *Id.*
[199] 2021 DOT OIG 737 MAX at p. 14.
[200] JATR Report at IV.
[201] *See* Jacobsen report.

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[203] *Id.*
[204] *Id.* at p. 4.
[205] *Id.*
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[212] *See* NTSB 787 Report
[213] *Id.* at pp. 72-73.
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[215] *Id.*
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[235] 467 U.S. 797 at pp. 819-820.

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[239] FAA Order 8110.8D at 2-2.
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[258] 70 FR 59931 (2005) at 59936.

[259] 69 FR 2969 (2004) at 2973.
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[291] *Id.* at p. 10.
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[301] *Id.* at pp. 3-4.
[302] *Id.* at n. 11.
[303] *Id.* at p. 33.
[304] *Id.*
[305] *Id.* at pp. 8-9.
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[311] The Boeing 737-8 MAX aircraft was added by FAA as the most recent model in a series of derivative models that were approved and added to the Boeing type certificate (TC), originally issued for the Boeing 737-100 on December 15, 1967. The FAA certified the 737-8 MAX through a streamlined "amended type certification" process which requires that only systems or areas that have been significantly changed, and areas affected by the change, need to be brought up to current regulatory standards, and other exceptions can be applied. 14 C.F.R. § 21.101. This process enables a manufacturer to introduce derivative aircraft models without FAA having to review and re-certify the entire aircraft design.
[312] Ewbank letter at p. 1.
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[314] *Id.*
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[317] *Id.*
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[319] *Id.*
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[343] *Id.* at pp. 5-6.
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[345] *See generally* 2019 CRS Cockpit Automation report.
[346] *See* Section II of this report.
[347] Boeing, "Aero No. 08," last visiting December 9, 2021, (hereinafter "Boeing Aero No. 08"), available at https://www.boeing.com/commercial/aeromagazine/aero_08/human_textonly.html.
[348] Boeing, "AERO QTR_2," last visited December 9, 2021, *available at* https://www.boeing.com/commercial/aeromagazine/articles/qtr_2_07/article_03_2.html.
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domestic airlines) globally, and accidents by Part 129 carriers (large foreign airlines) that occurred in the United States.
[351] NTSB data to Committee
[352] *Id.*
[353] *Id.*
[354] *Id.*
[355] *Id.*
[356] *Id.*
[357] *Id.*
[358] 2019 CRS Cockpit Automation report at p. 9.
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[360] *Id.*
[361] *Id.* at p. 11. Given the violent nature of this accident, the fact that only three persons died is a testament to the success of FAA's cabin safety requirements.
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[366] National Transportation Safety Board, "Crash of Pinnacle Airlines Flight 3701 Accident Report," January 9, 2007, *available at* www.ntsb.gov/investigations/AccidentReports/Reports/AAR0701.pdf.
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[386] *See* Whistleblower Protection Act of 1989 (Pub. L. No. 101-12, 103 Stat. 16 (Apr. 10, 1989)) (strengthening whistleblower protection, primarily against those claiming retaliation); *also see* Notification and Federal Employee Antidiscrimination and Retaliation Act of 2002 or "No Fear Act" (Pub. L. No. 107-174, 116 Stat. 566 (May 15, 2002)) (requiring agencies to notify and train employees, former employees, and applicants of their rights under antidiscrimination and whistleblower protection laws and requiring he Office of Personnel Management to report annually on certain topics regarding antidiscrimination and whistleblower protection); *also see* Whistleblower Protection Enhancement Act of 2012 (Pub. L. No. 112-199, 126 Stat. 1465 (Nov. 27, 2012)) (clarifying the scope of protected whistleblowing under the Whistleblower Protection Act and mandating broader outreach to inform certain federal employees of their whistleblower rights, among other things).
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[406] Dept. of Justice, “Boeing Charged with 737 Max Fraud Conspiracy and Agrees to Pay over $2.5 Billion,” January 7, 2021, *available at* https://www.justice.gov/opa/pr/boeing-charged-737-max-fraud-conspiracy-and-agrees-pay-over-25-billion.

[407] *Id.*

[408] The DOJ declined to meet with the Committee in its investigation, citing the ongoing nature of the deferred prosecution agreement with Boeing. Criminal Information, United States vs. Boeing, 4:21-CR-005-O (U.S. Dist. Ct. N.D. Texas), January 7, 2021, *available at* https://www.justice.gov/opa/press-release/file/1351331/download.

[409] 2020 DOT OIG 737 MAX certification report.

[410] 2021 DOT OIG 737 MAX audit report.

[411] Dept. of Transp. Office of Inspector General, “Audit Announcement: FAA's Oversight of Boeing 737 MAX Return to Service: Project No. 19A3006A002,” April 20, 2021, *available at* https://www.oig.dot.gov/sites/default/files/FAA%20Boeing%20Return%20to%20Service%20Audit%20Announcement_4.20.21.pdf.