



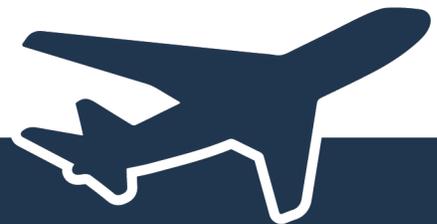
U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF INSPECTOR GENERAL

**Weaknesses in FAA's Certification and
Delegation Processes Hindered Its
Oversight of the 737 MAX 8**

FAA

Report No. AV2021020

February 23, 2021





Weaknesses in FAA's Certification and Delegation Processes Hindered Its Oversight of the 737 MAX 8

Requested by the Secretary of Transportation; the Chairmen of the House Committee on Transportation and Infrastructure and its Subcommittee on Aviation; the Chairman and Ranking Member of the Senate Committee on Appropriations, Subcommittee on Transportation, Housing and Urban Development, and Related Agencies; and Senator Richard Blumenthal

Federal Aviation Administration | AV2021020 | February 23, 2021

What We Looked At

The Federal Aviation Administration (FAA) has historically maintained an excellent safety record. However, two fatal accidents in 2018 and 2019 involving the Boeing 737 MAX 8 raised concerns about FAA's oversight and certification of civilian aircraft manufactured and operated in the United States. At the request of Secretary of Transportation Elaine L. Chao and several members of Congress, our office has undertaken a series of reviews related to FAA's certification of the MAX and its safety oversight, including the Agency's oversight of Boeing's Organization Designation Authorization (ODA). Our overall audit objective was to determine and evaluate FAA's process for certifying the Boeing 737 MAX series of aircraft. In this report, we focused on assessing (1) the effectiveness of FAA's guidance and processes for managing the certification of the 737 MAX 8 and (2) FAA's oversight of the Boeing ODA.

What We Found

While FAA and Boeing followed the established certification process for the 737 MAX 8, we identified limitations in FAA's guidance and processes that impacted certification and led to a significant misunderstanding of the Maneuvering Characteristics Augmentation System (MCAS), the flight control software identified as contributing to the two accidents. First, FAA's certification guidance does not adequately address integrating new technologies into existing aircraft models. Second, FAA did not have a complete understanding of Boeing's safety assessments performed on MCAS until after the first accident. Communication gaps further hindered the effectiveness of the certification process. In addition, management and oversight weaknesses limit FAA's ability to assess and mitigate risks with the Boeing ODA. For example, FAA has not yet implemented a risk-based approach to ODA oversight, and engineers in FAA's Boeing oversight office continue to face challenges in balancing certification and oversight responsibilities. Moreover, the Boeing ODA process and structure do not ensure ODA personnel are adequately independent. While the Agency has taken steps to develop a risk-based oversight model and address concerns of undue pressure at the Boeing ODA, it is not clear that FAA's current oversight structure and processes can effectively identify future high-risk safety concerns at the ODA.

Our Recommendations

We made 14 recommendations to improve the Agency's aircraft certification process and oversight of the Boeing ODA. FAA concurred with all 14 of our recommendations and provided appropriate actions and planned completion dates.

Contents

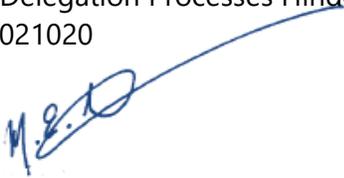
Memorandum	1
Background	3
Results in Brief	8
Gaps in FAA Guidance and Processes Impacted Certification of the 737 MAX 8	10
Management and Oversight Weaknesses Limit FAA’s Ability To Assess and Mitigate Risks With the Boeing ODA	25
Conclusion	41
Recommendations	41
Agency Comments and OIG Response	43
Actions Required	43
Exhibit A. Timeline of Major Events for the Certification of the Boeing 737 MAX 8	44
Exhibit B. Scope and Methodology	45
Exhibit C. Organizations Visited or Contacted	48
Exhibit D. Glossary of Terms	49
Exhibit E. Background on MCAS	51
Exhibit F. Selected Recommendations to FAA and Actions in Response to the Special Committee	52
Exhibit G. FAA’s Aviation Safety Group Offices Involved in Certification of the 737 MAX Aircraft—Organizational Structure (2017–Present)	53
Exhibit H. Selected OIG Recommendations to FAA on ODA Improvements	54
Exhibit I. Comparison of FAA ODA Oversight Offices for Type Certificate ODA Companies	55
Exhibit J. Major Contributors to This Report	56
Appendix. Agency Comments	57



Memorandum

Date: February 23, 2021

Subject: ACTION: Weaknesses in FAA's Certification and Delegation Processes Hindered Its Oversight of the 737 MAX 8 | Report No. AV2021020

From: Matthew E. Hampton
Assistant Inspector General for Aviation Audits 

To: Federal Aviation Administrator

Upholding safety is a primary mission of the Federal Aviation Administration (FAA). This includes overseeing the certification and safety of all civilian aircraft manufactured and operated in the United States. FAA has historically maintained an excellent safety record. However, two fatal accidents in 2018 and 2019 and the subsequent grounding of Boeing 737 MAX 8¹ aircraft raised questions and concerns about FAA's certification processes and oversight.

Specifically, on October 29, 2018, Lion Air Flight 610 crashed into the Java Sea shortly after departing Soekarno-Hatt International Airport, Jakarta, resulting in 189 fatalities. Just over 4 months later, on March 10, 2019, Ethiopian Air Flight 302 crashed shortly after departing Addis Ababa Bole International Airport, resulting in 157 fatalities, including 8 Americans. Both accidents involved the Boeing 737 MAX 8 aircraft model, which received FAA certification in March 2017.

At the request of the Secretary of Transportation and members of Congress,² our office has undertaken a series of reviews related to FAA's certification of the 737 MAX 8 and its safety oversight, including the Agency's oversight of Boeing's

¹ The official model number of the Boeing 737 MAX 8 is the 737-8.

² On March 19, 2019, Secretary of Transportation Elaine L. Chao requested that we compile an objective and detailed factual history of the activities that resulted in the certification of the 737 MAX 8. We also received similar requests from the Chairmen of the House Committee on Transportation and Infrastructure and its Subcommittee on Aviation; the Chairman and Ranking Member of the Senate Committee on Appropriations, Subcommittee on Transportation, Housing and Urban Development, and Related Agencies; and Senator Richard Blumenthal.

Organization Designation Authorization (ODA).³ Our audit objective is to determine and evaluate FAA's process for certifying the Boeing 737 MAX series of aircraft. On June 29, 2020, we issued our first report⁴ to the Secretary with a detailed, factual timeline of activities resulting in the certification of the 737 MAX 8. The report also provided timelines of events following the October 2018 Lion Air crash up until the March 2019 Ethiopian Air crash and concurrent related oversight actions and events related to FAA's ODA program. Exhibit A provides a detailed timeline of the major events in the certification of the 737 MAX 8.

This report builds on the information provided in the timeline report and includes additional analyses of FAA's processes for certifying the 737 MAX 8 aircraft, including its use of the ODA program. Specifically, we focused on assessing (1) the effectiveness of FAA's guidance and processes for managing the certification of the 737 MAX 8 and (2) FAA's oversight of the Boeing ODA. The third review in this series will focus on FAA actions taken during the decision to ground the aircraft and return it to service.

We conducted this audit in accordance with generally accepted Government auditing standards. Exhibit B details our scope and methodology, exhibit C lists the organizations we visited or contacted, and exhibit D is a glossary of terms.

We appreciate the courtesies and cooperation of Department of Transportation (DOT) representatives during this audit. If you have any questions concerning this report, please call me at (202) 366-0500.

cc: The Secretary
DOT Audit Liaison, M-1
FAA Audit Liaison, AAE-100

³ FAA created the ODA program in 2005 to standardize its oversight of organizational designees (e.g., aircraft manufacturers) that have been approved to perform certain functions on the Agency's behalf, such as determining compliance with aircraft certification regulations. ODAs are responsible for selecting and overseeing the employees who perform delegated functions, known as unit members, rather than FAA approving each individual designee.

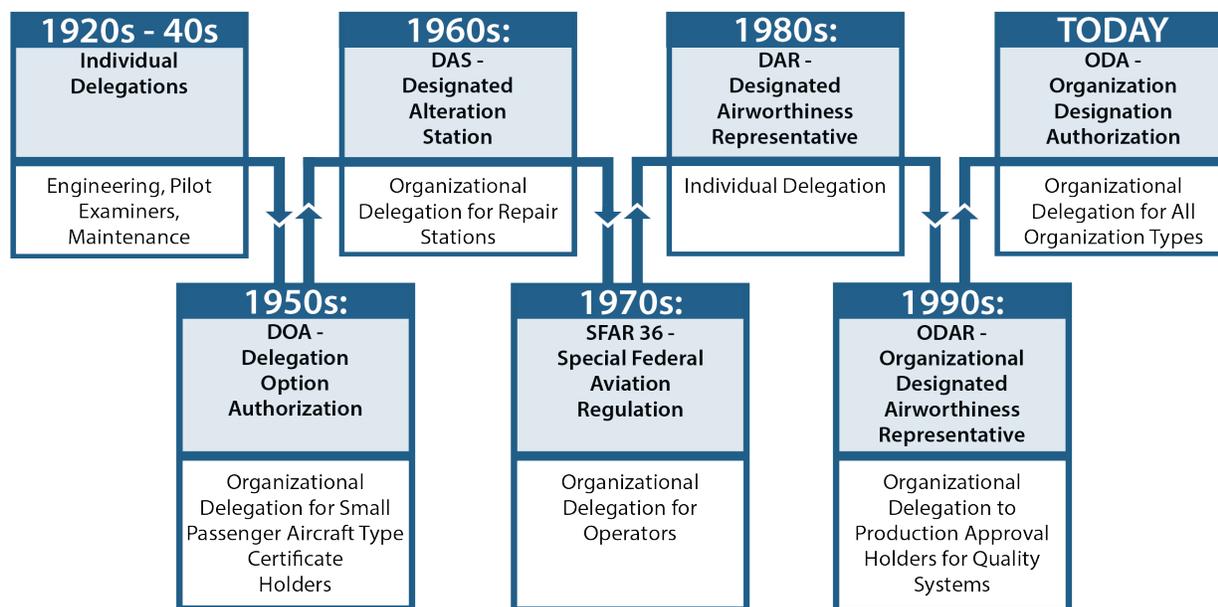
⁴ *Timeline of Activities Leading to the Certification of the Boeing 737 MAX 8 Aircraft and Actions Taken After the October 2018 Lion Air Accident* (OIG Report No. AV2020037), June 29, 2020. OIG reports are available on our website at <http://www.oig.dot.gov/>.

Background

FAA is charged with overseeing the safety and certification of all civilian aircraft manufactured and operated in the United States.⁵ This is a significant undertaking given that the U.S. civil aviation industry includes almost 292,000 aircraft, nearly 1,600 approved manufacturers, and more than 5,400 aircraft operators. Recognizing that it is not possible for FAA employees to oversee every facet of such a large industry, Federal law⁶ allows the Agency to delegate certain functions to private individuals or organizations, such as determining compliance with aircraft certification regulations. Designees can perform a substantial amount of critical certification work on FAA's behalf. For example, according to FAA data, in 2018 designated organizations at four U.S. aircraft manufacturers⁷ approved about 94 percent of the certification activities for their company's aircraft.

In 2009, FAA fully implemented the ODA program to standardize its oversight of organizations (e.g., aircraft manufacturers) that are approved to perform delegated functions on its behalf. ODA is the most recent of many delegation programs in aviation (see figure 1).

Figure 1. History of Aviation Delegation Programs



Source: OIG analysis of FAA data

⁵ 49 U.S.C. § 44702.

⁶ 49 U.S.C. § 44702(d).

⁷ The four manufacturers are Boeing, Gulfstream, Bell Helicopter, and Cessna, with Boeing being the largest.

Under previous organizational delegation systems, FAA was responsible for approving individual designees who would work on the Agency's behalf, known as authorized representatives. In the current model, the organization is authorized to perform approved functions on FAA's behalf, using company-appointed personnel, known as unit members. The company employs an FAA-approved ODA administrator who is responsible for overseeing the unit members, and then FAA is responsible for overseeing the ODA's processes and procedures. ODA unit member responsibilities may represent only a portion of an employee's duties.

When undertaking certification activities for a manufacturer with an ODA, FAA typically retains some level of involvement in significant design changes, novel designs, and critical compliance activities, based on the ODA's experience and FAA's judgment. According to FAA, the Agency always retains inherently governmental functions⁸ such as regulatory exemptions and functions for which an ODA is not authorized.⁹

While delegation is an essential part of FAA's certification process, our prior work identified issues with providing ODA oversight. For example, in 2015 we reported¹⁰ that FAA's oversight of ODA program controls was not systems- and risk-based,¹¹ as recommended by an aviation rulemaking committee.¹² Rather, the oversight was more focused on individual engineering projects and areas that we determined were low risk.

Under the ODA program, FAA's Boeing Aviation Safety Oversight Office, comprised of 47 FAA employees, oversees functions granted to Boeing.¹³ The Boeing ODA unit includes approximately 1,500 Boeing-designated ODA unit members. The ODA unit is housed within the Boeing Company, as shown in figure 2.

⁸ These functions include authority reserved for FAA approval, regulatory activity, and other areas so designated by Agency guidance such as interpretations of airworthiness standards, development of issue papers, and special conditions.

⁹ Some functions are discretionary based on which authorized functions FAA granted to the specific ODA, such as issuing airworthiness certificates, approving data for major repairs, and performing compliance inspections.

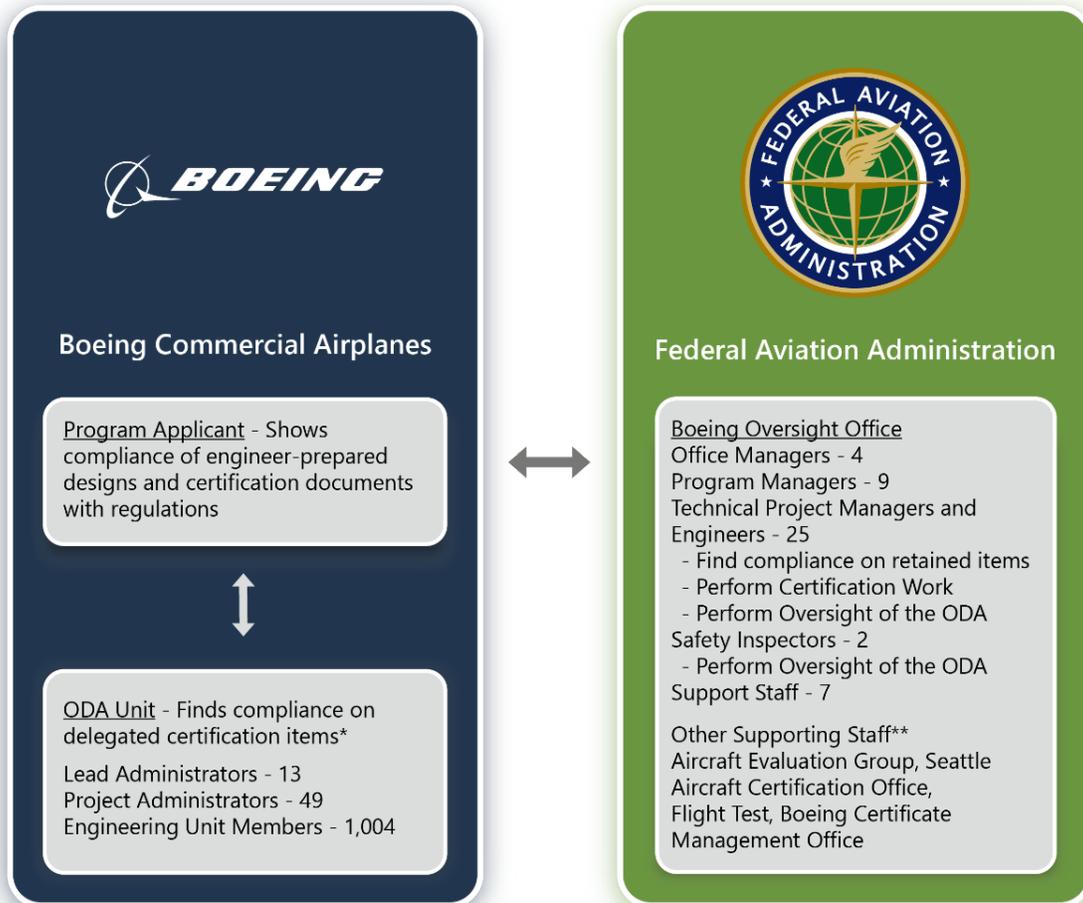
¹⁰ *FAA Lacks an Effective Staffing Model and Risk-Based Oversight Process for Organization Designation Authorization* (OIG Report No. AV2016001), October 15, 2015.

¹¹ Systems-based oversight shifts from focusing on individual project engineering work to holistically assessing whether ODA companies have the people, processes, procedures, and facilities in place to produce safe products, thus allowing FAA to focus its oversight on the highest-risk areas, such as new, innovative aircraft designs.

¹² Aircraft Certification Process Review and Reform Aviation Rulemaking Committee, a joint FAA and industry group, formed in response to a congressional mandate to study the aircraft certification process.

¹³ The oversight office includes 25 engineers and technical project managers who perform certification work as well as oversight, 2 inspectors that primarily perform oversight, plus additional program managers, supervisors, and support staff.

Figure 2. General Structure, Certification, and Oversight Process for the Boeing ODA and FAA’s Boeing Oversight Office



* Boeing production and manufacturing staff, including approximately 400 ODA inspection staff, are not included in this figure.

** Other supporting staff in the groups and offices listed here also have some oversight responsibilities of the Boeing ODA.

Source: OIG analysis of FAA data

FAA’s process for determining the certification basis of aircraft models is set forth in regulations (14 CFR Part 21) and guidance (FAA Orders 8110.48 and 8110.4c). Under the regulations and guidance, FAA can either award a type certificate¹⁴ (TC) for new aircraft models or an amended type certificate (ATC) for aircraft models that are derivatives of already-certificated aircraft¹⁵ (see figure 3 for an overview of the certification process).

¹⁴ An approval document issued by FAA that states a specific aircraft model is compliant with airworthiness regulations.

¹⁵ This is known as the “baseline aircraft.”

Figure 3. Key Phases in the Certification Process



* According to FAA Order 8110.4c and FAA Management, for complex projects, not all information related to the aircraft is known at this point in the process. Additional information is provided to FAA as it is developed by the applicant.

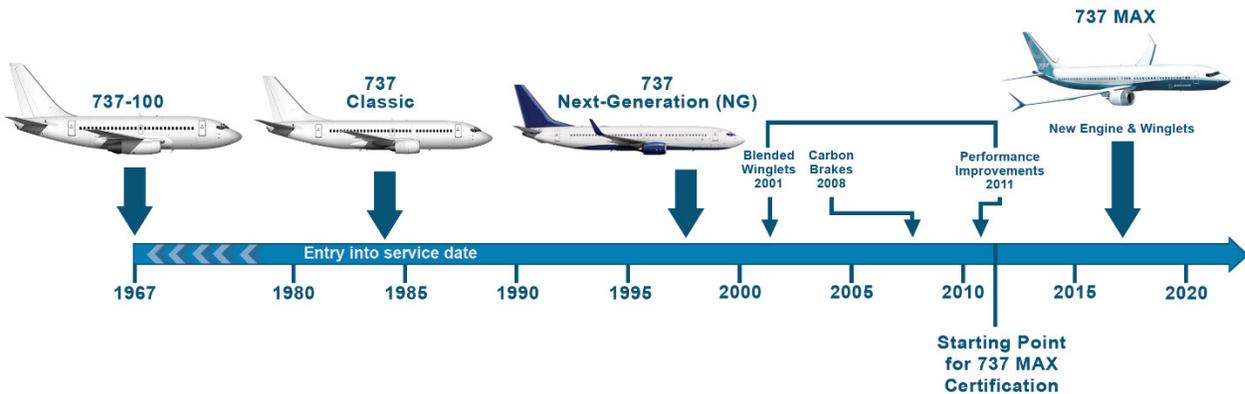
** The main difference between a new type certificate and an amended certificate is that under the amended type certificate only significantly changed areas need to be brought up to airworthiness requirements as of the date of the application.

Source: OIG analysis of FAA Order 8110.4C

The Boeing 737 MAX series¹⁶ is the fourth-generation model of Boeing’s 737 aircraft series (see figure 4). The first Boeing 737, the 737-100, received its type certificate on December 15, 1967—49 years before the Boeing 737 MAX 8. The 737 MAX 8 was certified as an ATC with the 737-800 (certified on March 13, 1998) as the baseline, part of the 737 Next Generation (NG) series.

¹⁶ The 737 MAX series includes the 7, 8, 9, 10, and 8200. The MAX 7, 10, and 8200 have not yet been certified by FAA.

Figure 4. Boeing 737 Family of Aircraft – 1967 to Present



Source: OIG analysis of FAA and Boeing data

According to FAA regulations, once applicants file for a new or amended type certificate, they have 5 years to complete the process. During the certification process, manufacturers are required to demonstrate compliance to the relevant standards. Those standards are largely contained in 14 CFR Part 25 for Transport Category Aircraft, and are amended as needed due to new technologies, in response to operational data or because of legislative mandates. The major milestones and requirements of the certification process for a new or amended type certificate are similar. However, if an aircraft model is certified under the ATC process, only systems or areas that have been significantly changed, and areas affected by the change, need to be brought up to current regulatory standards,¹⁷ and other exceptions can be applied.¹⁸

The 737 MAX 8 included a function in the flight control software—the Maneuvering Characteristics Augmentation System (MCAS)—that Boeing used in a new way on the 737 MAX. MCAS modifies aircraft handling characteristics in manual flight as an additional function of the existing aircraft speed trim system¹⁹ to compensate for changes in aerodynamics from the previous model caused by the MAX's larger engines and the placement of those engines on the wing. Specifically, MCAS can cause the airplane's horizontal stabilizer²⁰ to move without pilot input in certain, limited aircraft configurations²¹ related to airspeed and the

¹⁷ 14 CFR § 21.101, and Advisory Circular 21.101-A, more commonly known as the "Changed Product Rule."

¹⁸ According to 14 CFR § 21.101(b), applicants can also comply with earlier requirements when (1) an area, system, component, equipment or appliance are not affected by the change, (2) compliance with a later amendment does not materially improve safety, or (3) compliance with the latest amendment is impractical.

¹⁹ The speed trim system is a flight control system designed to improve the airplane's flight stability during operations in certain conditions when the autopilot is not engaged.

²⁰ A control surface near the tail of the airplane that controls up and down movement of the airplane.

²¹ These configurations include the plane being in manual flight (autopilot off) and the flaps being in an up position.

angle of the aircraft in the air—known as angle of attack (AOA).²² While not its primary intent, MCAS can, under certain failure conditions, have the effect of moving the plane’s nose down during manual flight if not counteracted by the pilot. (See exhibit E for more details on the functionality of MCAS.)

The accident report for the October 29, 2018, Lion Air accident states that MCAS was a significant contributing factor for the accident, after activating 24 times during the flight.²³ MCAS activated after receiving faulty data from one of the aircraft’s two AOA sensors—external sensors that measure the angle of the aircraft in the air. While the accident investigation for the March 10, 2019, Ethiopian Air accident remains ongoing, the preliminary and interim reports²⁴ also point to MCAS as a potential contributory factor to the accident.

On March 13, 2019, FAA issued a grounding order for the 737 MAX fleet. After reviewing and approving Boeing design changes to the aircraft, the Agency rescinded the grounding order on November 18, 2020.

Results in Brief

Gaps in FAA guidance and processes impacted certification of the 737 MAX 8.

While FAA and Boeing followed the established certification process for the 737 MAX 8, we identified limitations in FAA’s guidance and processes that led to a significant misunderstanding of MCAS, the flight control software identified as contributing to the Lion and Ethiopian Air accidents. First, FAA’s certification guidance does not adequately address integrating new, advanced technologies into existing aircraft models. For example, FAA’s guidance lacks clarity on assessing aircraft areas that have changed from previous designs. The Agency relies on the manufacturer to identify which changes from previous aircraft models are significant. As a result, because Boeing did not identify MCAS as significant, FAA did not focus on the system during certification reviews. Second, FAA did not have a complete understanding of Boeing’s safety assessments performed on MCAS until after the Lion Air accident. For example, although Boeing prepared internal documents detailing some safety implications with MCAS, key assumptions related to pilot reaction to the system were not included in certification deliverables that the company submitted to FAA. Finally,

²² Angle of attack (AOA) is the difference between the pitch angle (nose direction) of the airplane and the angle of the oncoming wind.

²³ Komite Nasional Keselamatan Transpotasi Republic of Indonesia. KNKT.18.10.35.04. FINAL. 2019.

²⁴ Federal Democratic Republic of Ethiopia, Ministry of Transport. Aircraft Accident Investigation Bureau. Preliminary Report. Interim Report, March 2020.

communication gaps further hindered the effectiveness of the certification process. FAA's certification flight test team was aware that Boeing had significantly revised MCAS. However, due to a lack of effective coordination within FAA and between FAA and Boeing, some of FAA's certification engineers and personnel responsible for approving the level of airline pilot training told us they were unaware of Boeing's changes to MCAS and their impact. 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. These issues limited FAA's ability to make an informed decision regarding the safety of the aircraft when approving Boeing's certification and pilot training.

Management and oversight weaknesses limit FAA's ability to assess and mitigate risks with the Boeing ODA.

FAA certification engineers delegated an increasing amount of 737 MAX certification work to the Boeing ODA during the 2012–2017 certification—as much as 87 percent of certification plans near the end of the process.²⁵ Since our 2015 report, FAA has taken steps to improve its ODA oversight guidance and has conducted a pilot test of its revised process for risk-based oversight. However, more than 5 years after our recommendation, FAA has not yet implemented a risk-based approach to ODA oversight, and it remains to be seen how the Agency will incorporate any lessons learned from the 737 MAX accidents into its new approach. Additionally, we found that engineers in FAA's Boeing oversight office continue to face challenges in balancing certification and oversight responsibilities due to an organizational culture driven by the demand to meet certification schedules and issues with prioritizing oversight, as well as Agency resource gaps. For example, 15 of 24 FAA office managers and personnel we interviewed expressed concerns with the current level of staffing resources and expertise in the office. Further, staff expressed concerns about frequent staff turnover in FAA's Boeing oversight office potentially leading to a loss of institutional knowledge. Finally, the Boeing ODA process and structure do not ensure the ODA is adequately independent. We reviewed FAA and Boeing documents regarding Boeing ODA unit members feeling pressure from Boeing company management to approve items or affirm compliance with regulations without sufficient time to perform a review. This pressure could potentially impact aircraft safety and ultimately the flying public. FAA has taken some enforcement and compliance actions against Boeing related to these and other concerns. While the Agency has taken steps to develop a risk-based oversight model and to address the root causes of undue pressure at the Boeing ODA, it is not clear that

²⁵ According to FAA managers, it is typical for delegation to increase over time as the Agency gains confidence in Boeing's capabilities after initially retaining involvement.

FAA's current oversight structure and processes can identify future high-risk safety concerns at the ODA.

We made 14 recommendations to improve FAA's aircraft certification process and oversight of the Boeing ODA.

Gaps in FAA Guidance and Processes Impacted Certification of the 737 MAX 8

While FAA and Boeing followed the established transport category airplane certification process for the 737 MAX 8, gaps in guidance, limited FAA reviews of Boeing's safety assessments, and poor communication impacted certification of the 737 MAX 8. FAA's certification guidance does not adequately address integrating new, advanced technologies into existing aircraft models. Additionally, weaknesses in FAA guidance led to knowledge gaps and an incomplete understanding of safety assessments performed on new flight control software until after the Lion Air accident. Finally, communication gaps between FAA certification offices, and between FAA and Boeing, hindered the effectiveness of the certification process.

FAA's Guidance Does Not Adequately Address Integrating New Technologies Into Existing Aircraft Models

Overall, FAA followed its established certification process for the 737 MAX 8, which began in early 2012 when Boeing submitted its initial application for an amended type certificate. However, we identified a number of concerns regarding FAA's guidance related to reviewing and accepting amended type certificate applications, as follows.

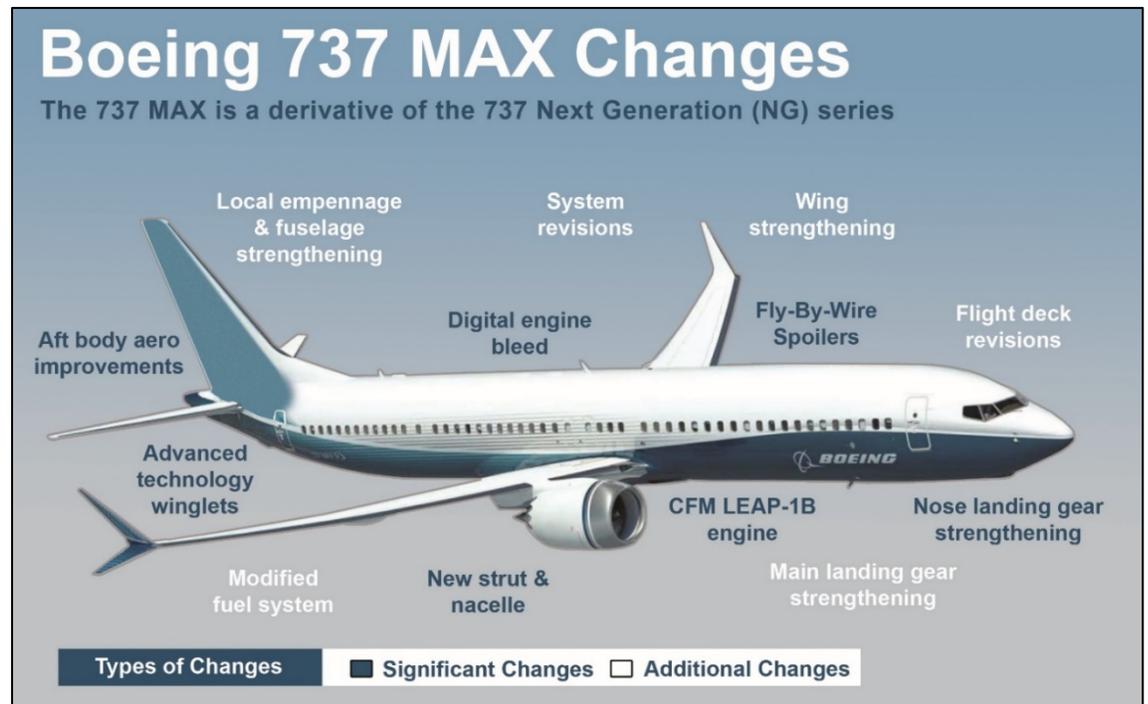
FAA's Guidance Lacks Clarity on Assessing Aircraft Areas That Have Changed From Previous Designs

Under FAA's certification process, if an aircraft model is certified under the amended type certificate process, only systems or areas that have been significantly changed need to be brought up to current regulatory standards.²⁶ Early in the certification process, FAA accepted Boeing's assessment that the MAX

²⁶ According to FAA, these processes are globally accepted and harmonized with international aircraft manufacturing certification and changed product guidance.

was similar enough to the base aircraft (737-800) that it could proceed as a derivative of an already-certified aircraft. (See figure 5 for a diagram of what FAA identified as the significant changes to the aircraft. MCAS was included in “system revisions.”)

Figure 5. Significant Changes From the 737 NG to the 737 MAX Aircraft



Source: OIG analysis of FAA and Boeing data

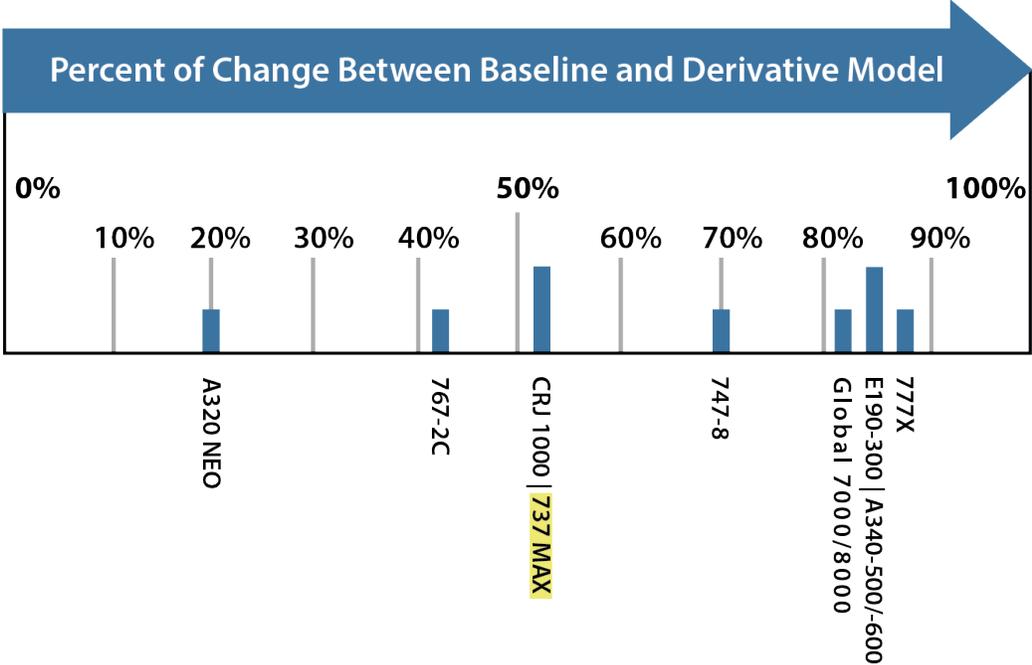
While FAA was aware that MCAS was being installed on the 737 MAX, it was not an emphasis of FAA’s certification efforts. According to FAA, certification engineers focused their involvement on areas such as the aircraft’s larger engines, fly-by-wire spoilers, and landing gear changes, which qualified as significant under FAA guidance. Under the current system, the Agency relies initially on the applicant to identify significant changes, and FAA then reviews and assesses those determinations. This was also the case at the time FAA was reviewing the MAX certification proposal. Boeing did not assess its planned flight systems revisions, including MCAS, as significant in its initial application.

FAA regulations, known as the Changed Product Rule,²⁷ and related guidance do not have a set threshold for the overall number of changes that would require a

²⁷ The Changed Product Rule consists of 14 CFR § 21.19 and § 21.101.

new type certificate, but the guidance²⁸ does specify certain types of changes that would trigger a new type certificate. For example, FAA’s guidance states that a change from an all metal airplane to an all composite airplane, or a change in the number of engines, constitutes an extensive design change. However, according to FAA officials, the specific changes made in the MAX certification proposal did not reach those thresholds, and the overall percentage of change on the MAX was in line with other recent amended type certificate projects (see figure 6).

Figure 6. Percentage of Change in Recent Amended Type Certificate Projects



Source: OIG review of FAA data

Similarly, we did not identify any substantial changes from the 737-800 to the 737 MAX, as defined in this guidance, that would have clearly required that Boeing apply for a new type certificate. However, this guidance is part of the problem, according to certification personnel we interviewed. Eighteen out of 20 FAA managers, engineering specialists, and pilots who we interviewed on this topic stated the existing guidance needed revisions, such as adding specificity and limitations on its applicability to new projects. This is because applicants can potentially use that lack of specificity—in combination with past FAA decisions—to avoid upgrading specific systems that would add additional costs to the

²⁸ FAA Advisory Circular 21.101-1A, September 3, 2010.

airplane's development and production. FAA management recognizes the need to make improvements in this guidance but also noted that the system would be less safe overall without it because manufacturers would have less incentive to make incremental safety improvements or upgrades, such as cockpit avionics enhancements.

In accordance with the Changed Product Rule and associated guidance, FAA has the authority to grant exceptions for changed areas to be certified to an older standard in certain cases, such as when the change is not deemed significant or does not contribute materially to the level of safety. For example, FAA granted Boeing exceptions for changes to certain items in the 737 MAX aircraft's interior, such as lavatories, as the Agency agreed that changes to those items from the 737-800 were not significant under the Changed Product Rule.

While FAA's regulations do not contain a limit on the number or types of exceptions that can be granted—as long as exceptions meet certain requirements²⁹—Agency officials stated that one of their lessons learned from the certification of the MAX is the need to limit the exceptions that it grants. For example, FAA did not require Boeing to upgrade the 737 MAX to a more modern flight crew alerting system, such as the Engine Indicating and Crew Alerting System, used by Boeing on other aircraft since 1982 to provide clear pilot warnings. According to Boeing, the inclusion of such a system would have impacted the company's goal of maintaining a common flight deck philosophy within the 737 fleet of airplanes and jeopardized maintaining the same type rating³⁰ between the 737 MAX and the 737 NG. The FAA Director of System Oversight told us that his office plans to work with manufacturers to limit exceptions for future amended type certification projects when manufacturers request them for their projects, and has already done so on an aircraft currently undergoing certification.

The Special Committee on the FAA's Aircraft Certification Process issued a report in January 2020 with recommendations about updating guidance, roles, and responsibilities related to aircraft changes.³¹ In response,³² FAA stated that the Changed Product Rule and associated guidance have evolved over the past 2 decades to harmonize with international partners due to the global nature of

²⁹ Under Part 21.101(a), FAA can grant exceptions if the Agency determines that the change does not materially affect safety, the system/area under examination is not affected by the change, or if requiring compliance with the applicable regulation would be impractical.

³⁰ A type rating is an endorsement on the pilot certificate indicating that the pilot has completed the required training and testing for a specific make, type, and/or series of aircraft (e.g., Boeing 747-400).

³¹ *Official Report of the Special Committee to review the Federal Aviation Administration's Aircraft Certification Process*. January 16, 2020.

³² *Response to Official Report of the Special Committee on the Federal Aviation Administration's Aircraft Certification Process*. Aviation Safety April 2020 Final Report.

the transport airplane industry and the need for consistent regulations. FAA re-chartered the international coordination team in November 2020; it plans to hold the first meeting in February 2021 to further review this guidance and then develop recommendations to address regulatory and policy gaps that ensure a consistent, global approach. See exhibit F for a summary of the Agency's proposed actions and milestones on this issue and other key areas from this report.

Gaps in the Changed Product Rule, as well as the complexity of the Rule, contributed to issues with the 737 MAX 8 certification. Specifically, the lack of time limits or limits on the number of derivatives under the rule allowed Boeing to certify the aircraft as a fourth generation derivative, almost 50 years after the first 737 was certified in 1967. This means some of the features on the 737 MAX 8 have not changed since they were initially certified in 1967, such as the design of the flight control computers to be independent of each other.³³ In addition, FAA engineers and managers stated that the Changed Product Rule can lead the Agency to an overly narrow focus on specific areas of upgrades, and not on how those upgrades would interact with other areas of the plane and affect the airplane as a whole.

FAA's Processes May Not Adequately Address How To Assess Potentially Novel or Unusual Design Features

The Boeing 737 MAX certification has also raised questions about FAA's processes and criteria for determining which design features require additional scrutiny because they are novel or unusual—i.e., not covered by existing regulations. Under FAA's processes, the Agency can prescribe a special condition for new features on an aircraft that are not covered by existing regulations to ensure the new feature has an equivalent level of safety to those regulations. However, the Agency has not established specific guidance on making this determination.

Issues with MCAS have raised questions about how and when a system or feature should be considered novel or unusual. While FAA prescribed nine special conditions for the 737 MAX 8, Boeing did not identify MCAS as novel or unusual in early certification documents—and therefore FAA did not prescribe a special condition for MCAS. According to the company, the design feature had been covered under existing regulations³⁴ relating to flight control systems, in addition to being included on the military Boeing 767 refueling tanker. However, the version of MCAS installed on the 767 tanker differed from the version of MCAS

³³ This flight control computer design required Boeing to use a federated architecture in order to make the computers communicate and interact.

³⁴ Existing regulations including §§ 25.671, 25.672, 25.1309, and 25.1329.

on the 737 MAX, including using inputs from both angle of attack sensors rather than only one (see table 1).

Table 1. MCAS Differences – 767 Tanker vs. 737 MAX

MCAS Feature	767 Tanker	737 MAX: 2012–2019 ³⁵
Uses median input from AOA sensors on both sides of aircraft	Y	N <i>(only AOA sensor data from active side)</i>
Activates repeatedly	N	Y
Only active when autopilot disengaged	Y	Y
Automated pilot control column cutout ³⁶	Y	N

Source: OIG analysis of Boeing and FAA data

We found mixed views both within FAA and externally regarding whether MCAS should have been considered novel or unusual, therefore resulting in additional scrutiny. This issue was complicated by regulations related to systems such as MCAS, which are spread across multiple technical areas. For example, in our interviews with FAA office managers, engineers and pilots, there were conflicting opinions in retrospect about whether MCAS was novel or unusual, with some FAA representatives stating they were unsure. Further, the Joint Authorities Technical Review (JATR)³⁷ team determined that MCAS on the 737 MAX controlled the aircraft’s movements in a new way. According to FAA, the Agency has since reached consensus that a special condition was not required for MCAS on the 737 MAX, but acknowledged that the Agency should reevaluate the criteria.

³⁵ MCAS features listed here reflect what was present on the aircraft until the time of the grounding order; MCAS required revisions in order to return the fleet to service.

³⁶ The column cutout will electronically disable the airplane’s trim system if the pilot’s control column is pulled back beyond a specified point.

³⁷ The JATR is a team consisting of representatives of regulators from 10 countries (including the United States) that was chartered by FAA on June 1, 2019, to examine the Agency’s certification of the 737 MAX 8. The JATR issued a document containing observations, findings, and recommendations on October 11, 2019.

Weaknesses in FAA Guidance Led to Knowledge Gaps and an Incomplete Understanding of Safety Assessments

Due in part to weaknesses in FAA's processes and guidance, FAA engineers lacked necessary knowledge during the Boeing 737 MAX certification process that limited their ability to make informed decisions about the safety of the aircraft.

Process and Guidance Limitations Resulted in FAA Certification Engineers Being Unaware of Key Changes to MCAS

FAA certification engineers were not aware of significant changes to MCAS that occurred during the course of the certification process. Specifically, Boeing continued to revise and refine MCAS during the flight testing process and made a significant revision to MCAS in early 2016, known as "Revision D." In this revision, Boeing changed the parameters under which MCAS would activate to include much slower airspeeds.³⁸ It also increased the maximum range of MCAS from 0.55 degrees to 2.5 degrees.³⁹ While not its primary intent, this meant that MCAS could push the nose of the aircraft downward in manual flight, if not counteracted by the pilot, with a maximum range of 2.5 degrees of movement each time it activated.⁴⁰

In this revision, Boeing also included an assessment of functional hazards related to the software, describing hazard conditions, failure conditions, and associated effects. One of the noted hazards was an uncommanded MCAS activation that continued until the pilot took action. When developing this risk assessment, Boeing pilots and engineers made an engineering assumption that commercial pilots would recognize the effect of unintended MCAS activation as a runaway stabilizer⁴¹—a scenario which is covered in commercial pilot training—and react accordingly.

While Boeing tested a single, unintended activation of MCAS, it did not test repeated MCAS activations. Boeing engineers and test pilots, in discussions, assumed multiple activations of MCAS to be no worse than a single activation of MCAS. However, Boeing did not include this conclusion in certification

³⁸ Following this revision, MCAS could now activate at speeds of 0.2 to 0.84 Mach, whereas it could previously only activate at speeds above 0.67 Mach.

³⁹ The range of movement allowed in the horizontal stabilizer decreases as the airspeed increases.

⁴⁰ Specifically, MCAS uses the aircraft's horizontal stabilizer (near the tail of the aircraft) to control the angle of the aircraft, and the range of MCAS is the angle of movement of the stabilizer.

⁴¹ A technical fault resulting in continuous unintended movement of the horizontal stabilizer.

deliverables provided to FAA. Further, Boeing’s system safety assessments did not fully account for how pilots would react to a multi-failure scenario. Boeing noted in these assessments that it did not simulate an accumulation or combination of failures leading to unintended MCAS activation, nor their combined flight deck effects.

Despite these significant revisions, Boeing did not directly inform FAA certification engineers of the increased MCAS range that was included in internal coordination documents for Revision D.⁴² While FAA provides guidance on how to perform required safety analyses, it does not specify that internal revision documents are certification deliverables. Because these revision documents were not required certification deliverables, the company did not submit them to FAA for review or acceptance. As a result, FAA certification engineers told us that they were unaware of the increased range of MCAS, as well as the fact that MCAS could now activate at slower speeds. Because they did not know these facts, the FAA certification engineers were not able to develop a full understanding of how MCAS worked and its potential impact on the aircraft as a whole.

In addition, Boeing analyzed potential hazards from the loss of AOA function in its Single and Multiple Failure document. Boeing uses this document to “prevent simultaneous failure from a single threat event which causes loss of continued safe flight and landing.” While FAA provides guidance on how to perform required failure mode analysis, Agency guidance⁴³ does not advise manufacturers to submit the Single and Multiple Failure document as a certification deliverable, nor does the guidance specify which engineering assumptions need to be included. As a result, Boeing considered this failure probability analysis an internal document only and did not submit it to FAA as a required certification deliverable, and FAA did not have to review or approve the document as part of the certification process.

However, according to FAA, some aspects of Boeing’s analysis from the Single and Multiple Failure document—such as assumptions related to how pilots would react to erroneous MCAS activation and the impact of not reacting in a timely manner—should have been included in system safety assessments later provided to the Agency as certification deliverables. Had they been included, FAA certification engineers might have had a better understanding of how and when MCAS activated and its interaction with other key flight controls on the 737 MAX. According to the guidance, assumptions on crew reactions should be considered when completing in the safety assessments in order to show compliance with regulations.

⁴² Revision D is where the major changes to MCAS first occurred; subsequent MCAS Revision E (dated July 5, 2016) configurations were the versions actually installed on the aircraft as of the date of ATC issuance.

⁴³ Advisory Circular 25.1309-1A; June 21, 1988.

FAA Lacks Up-to-Date Guidance on Required Safety Assessments, and When To Receive and Review Them in the Certification Process

FAA's guidance on system safety assessments is more than 30 years old. The current guidance,⁴⁴ which was also used during the MAX certification process, was last updated in 1988, and relies heavily on qualitative analysis and engineering judgment to identify and classify failure conditions and determine how to assess them for regulatory compliance.⁴⁵ In its 2019 report on the 737 MAX, the National Transportation Safety Board noted that more detailed and validated methods of examining human factors exist today than were in place when FAA developed and implemented this guidance.⁴⁶ During its internal review of MCAS certification, FAA noted that under an unofficial, never-issued but sometimes-used Agency guideline known as the "Arsenal" version of Advisory Circular 25.1309,⁴⁷ Boeing would not have been permitted to use solely qualitative means to validate its assumptions related to pilot reactions.⁴⁸ While Boeing used the Arsenal on newer aircraft type designs such as the 787 and the 777-9,⁴⁹ the company did not use it to demonstrate compliance during the MAX certification process, as agreed to by FAA.

In addition, Boeing did not deliver the final versions of two key system safety assessments—the horizontal stabilizer system and the Enhanced Digital Flight Control System—until late in the MAX certification process. The Master Certification Plan stated that FAA engineers would retain responsibility for reviewing these safety assessments both of which included details on MCAS. However, Boeing did not present the formal versions of these system safety assessments to FAA for the first time until November 2016 and January 2017—more than 4 years into the 5-year certification process.

According to FAA management, it is not unusual for manufacturers to complete and submit the final versions of safety assessments toward the end of the certification process. This is because, according to FAA, these safety assessments can change throughout the certification process as the manufacturer makes revisions to the aircraft. Manufacturers are required to submit risk management plans to FAA prior to Agency flight testing, and according to FAA, Boeing provided these plans in the form of preliminary system safety assessments. There

⁴⁴ Advisory Circular 25.1309-1A. System Design and Analysis. June 21, 1988.

⁴⁵ 14 CFR §§ 25.1309 (b), (c), and (d).

⁴⁶ National Transportation Safety Board Report ASR-19-01. September 19, 2019.

⁴⁷ As of 2019, FAA prepared a new cost-benefit analysis of a proposed rule updating both 14 CFR § 25.1309 and the associated Advisory Circular, and is planning to release a Notice of Proposed Rulemaking.

⁴⁸ This review produced documentation that included required supervision records and a draft report. According to FAA management, the report was going through management review and comment at the time of the Ethiopian accident, at which time the Agency considered it overtaken by events.

⁴⁹ The 787-8 model was a new type design, and the 777-9 model (pending certification) is a derivative type design.

is no requirement to provide revisions of these assessments until the final versions are submitted. However, on the 737 MAX certification project, Boeing did not include significant revisions in those final reports. As a result, FAA did not have comprehensive information when performing its final reviews of these two critical safety assessments. In addition, in a 2016 internal email, a Boeing ODA unit member advisor noted his concerns regarding a lack of clear policy for notifying FAA of changes late in the certification process, as well as a lack of confidence that FAA and ODA unit members clearly understood what they were approving when the company made changes after the start of certification flight testing.

In its response to the January 2020 Official Report of the Special Committee on the FAA's Aircraft Certification Process, FAA stated it was going to evaluate existing aircraft certification regulations, policies, and industry standards related to the human-machine interface, explore improved safety assessment methodologies, and better integrate human factors evaluation methods. The Agency recently launched a policy review team and has an ongoing rulemaking project concerning system safety assessments with the intent to publish a Notice of Proposed Rulemaking by August 2021.

FAA Did Not Perform a Detailed Assessment of MCAS Until After the Lion Air Accident

Due in part to these weaknesses with FAA's guidance and processes, FAA engineers did not have a full understanding of MCAS until after the Lion Air accident. This resulted in a series of meetings with Boeing in early January 2019—nearly 20 months after the MAX began commercial operation—during which FAA began to ask detailed questions related to MCAS functions and parameters and how Boeing certified the software.

FAA's review found that Boeing complied with current processes and procedures but noted Boeing's document traceability and clarity of explanations were lacking in its revisions to MCAS and other system certification documents. This FAA review determined that an independent reviewer of the safety assessment would not have been able to fully understand how MCAS worked or how interactions with other systems could impact the safety of the airplane.

FAA's findings were summarized in supervision records and a draft report that was never finalized. According to FAA management, the report was going through management review and comment at the time of the Ethiopian accident, at which time the Agency considered it overtaken by events. FAA management stated that they did not finalize the report because they realized they would be recertifying an updated system.

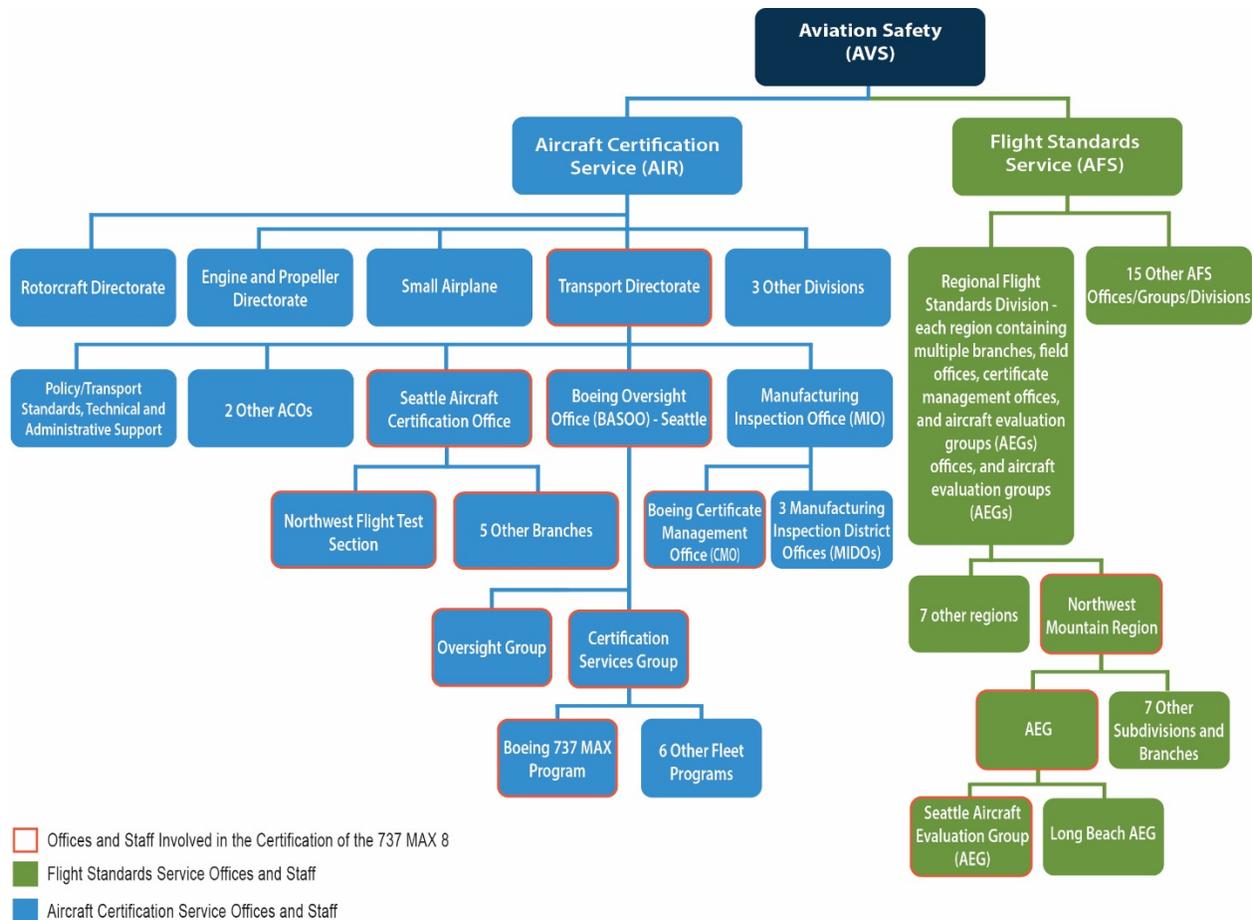
Communication and Coordination Gaps Impede Knowledge Sharing Between FAA and Boeing and Among FAA Offices

Communication channels between FAA Aircraft Certification and Flight Standards offices are not clear and do not ensure all critical knowledge is shared. For example, while FAA certification engineers were unaware of the significant changes contained in MCAS Revision D, Boeing briefed FAA flight test personnel in May 2016 about the increased maximum range of MCAS in the flight control computer actually installed on the 737 MAX 8 test aircraft. However, Boeing did not directly inform FAA certification engineers of the change. According to information provided by Boeing, the company presented some details about the changes to MCAS as part of meetings with foreign regulators beginning in July 2016. We confirmed attendance of some FAA certification personnel at these meetings. However, these meetings were meant to inform international authorities about the aircraft certification basis,⁵⁰ and they occurred after FAA had already authorized flight testing on the 737 MAX. Further, according to FAA, because the meetings were not intended as a forum in which to present certification material to FAA for review, approval, or acceptance, the Agency does not consider these meetings to be the appropriate avenue in which to share new certification data.

Employees from multiple branches, groups, divisions, and offices within FAA are involved in the certification process. Engineering and flight test staff working in at least three different offices and divisions within FAA's Aircraft Certification Service play key roles in any certification program, and aviation safety inspectors within FAA's Flight Standards Service also have a critical role (see figure 7).

⁵⁰ The "certification basis" for an aircraft model is where the manufacturer has identified the applicable requirements, including detailed airworthiness standards, as well as project-specific requirements such as exemptions, special conditions, and equivalent level of safety findings.

Figure 7. FAA Aviation Safety Units Involved in Certification of the 737 MAX Aircraft – Organizational Structure, 2012–2017



Source: OIG analysis of FAA data

Further, the organizational structure of FAA’s Aircraft Certification Service underwent a major reorganization in 2017, potentially further complicating the already complex relational dynamics. (See exhibit G for a depiction of the FAA Aviation Safety group organizational structure since 2017.)

The Aircraft Evaluation Group (AEG),⁵¹ a group of aviation safety inspectors from FAA’s Flight Standards Service, was also unaware of the full capabilities of MCAS. This group is tasked with determining the appropriate type rating and levels of pilot training for aircraft that are undergoing evaluation for a type certificate or amended type certificate. As a result, this group was making key decisions regarding the information provided to pilots without having full knowledge of

⁵¹ The AEG was renamed the Aircraft Evaluation Division in August 2017. Since the certification of the 737 MAX took place prior to the name change, we will refer to the office as the AEG throughout this report.

the function. For example, in early 2016, AEG approved removing any mention of MCAS from flight crew manuals. The AEG representative responsible for approving the change stated that FAA, as a result of the information they had at the time, based the decision on the understanding that MCAS remained as originally designed.

AEG did not focus on MCAS when discussing pilot training with Boeing in part because of how Boeing chose to present the system. According to an FAA Flight Standards representative and an internal email between Boeing employees, an early Boeing program goal was to keep the same type rating as earlier 737 aircraft and to keep costs down by avoiding simulator training for MAX pilots. The internal messages discussed how Boeing wanted to present it to FAA as an additional function of the existing speed trim system, as well as its ODA's concurrence with that approach, while still using the term "MCAS" internally. Due to how MCAS was presented, it was not an area of emphasis in AEG's discussions with Boeing regarding pilot training, which focused instead on areas such as warnings that the aircraft is turning too steeply when the autopilot was active and flight displays. As a result, even if this group had recommended simulator training, instead of the classroom or computer training that it settled on,⁵² the training would not likely have included MCAS.

In addition, while FAA has guidance for AEG on evaluating aircraft, determining pilot qualifications, and identifying differences in pilot training and qualifications between aircraft with the same type certificate, it lacks written policies and procedures in key areas. These gaps further hindered communication and record keeping between FAA and Boeing regarding key decisions. For example:

- FAA did not formally communicate approval of the training level to Boeing until 7 months after Boeing satisfactorily completed testing, as compared to early approvals from Transport Canada and the European Aviation Safety Agency (EASA).
- FAA did not document its approval to remove references to MCAS from the flight crew operations manual in official correspondence; rather, Boeing requested it via email and FAA approved it verbally in a subsequent meeting, according to the responsible FAA AEG representative.
- FAA did not consistently keep formal records of operational tests.

⁵² This is known as "Level B" training. The levels of training are defined in FAA Advisory Circular 120-53B.

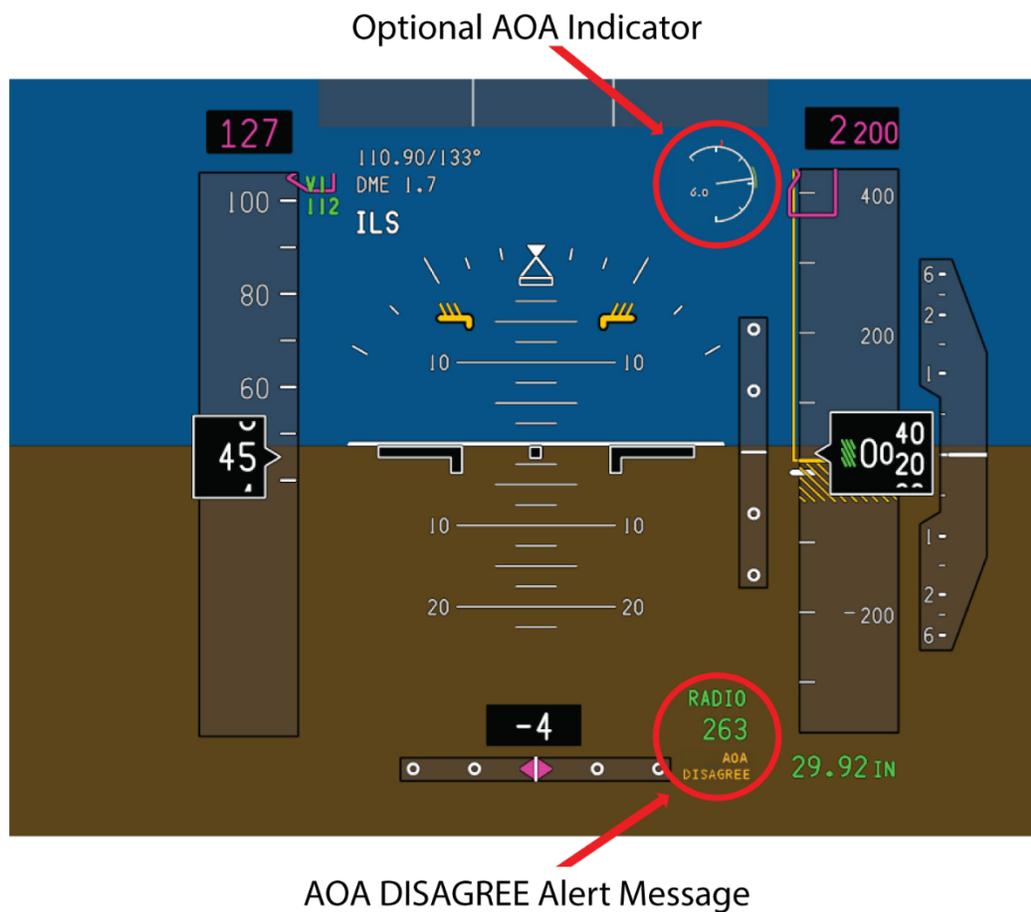
- FAA has not documented the Flight Standardization Board (FSB)⁵³ process. For example, while FAA established a FSB process under Advisory Circular 120-53B, AEG representatives on the 737 MAX program stated that the process is only the baseline for evaluations. In addition, one FAA operational AEG pilot stated that, as a result of not having a written policy, AEG representatives have differing interpretations of what is required, resulting in inconsistent flight tests for different manufacturers across the country.

FAA has acknowledged a need for improvement in its internal communication and coordination and stated that the Agency has begun these efforts, including organizational changes in 2017. In its response to the Official Report of the Special Committee on the FAA's Aircraft Certification Process, FAA stated it is taking steps to engage its workforce regarding aircraft certification and flight standards integration through a management memorandum to reinforce expectations. The Associate Administrator for Aviation Safety issued this memorandum on June 15, 2020, and the Agency also planned to identify and capture early opportunities to improve collaboration and increase integration by the end of fiscal year 2020. FAA also plans to institutionalize new norms through policy changes and completion of business group reorganizations by the end of 2021.

Further, there were communication gaps between Boeing and FAA even after the MAX received certification. For example, Boeing did not inform FAA of a cockpit alert issue until after the Lion Air accident. Specifically, in August 2017, Boeing discovered that not all 737 MAX aircraft were equipped with an alert designed to notify pilots when the two AOA sensors disagree by more than 10 degrees for at least 10 seconds. According to Boeing representatives, Boeing had intended this cockpit alert message to be standard on all 737 MAX 8 aircraft within the flight control computer system (see figure 8).

⁵³ FAA typically establishes an FSB when certificating large jet or propeller aircraft. It consists of members of AEG, FAA operations inspectors for the initial operator of the aircraft, representatives from the Office of Safety Standards, and other technical advisors if necessary. One of the FSB's mandates is to develop training objectives for normal and emergency procedures and maneuvers.

Figure 8. AOA Disagree Message and AOA Indicator



Source: FAA

According to Boeing representatives, they analyzed the issue and determined that the cockpit alert was not “necessary for the safe operation of the airplane” because there were no required procedures or pilot actions associated with the alert. Boeing documented the problem and planned to have the problem corrected for the entire MAX fleet by late 2020. According to Boeing representatives, the AOA disagree cockpit alert message issue was included in updated certification documents in September 2017 that were approved by an ODA engineering unit member on FAA’s behalf. Boeing did not have to submit a formal notification of the issue directly to the FAA oversight office since company analysis had determined that there was not an “operational impact” as a result of the cockpit alert issue. Documentation we reviewed from February 2019 and FAA representatives we interviewed agreed with Boeing’s determination that it was not an unsafe condition.

Management and Oversight Weaknesses Limit FAA's Ability To Assess and Mitigate Risks With the Boeing ODA

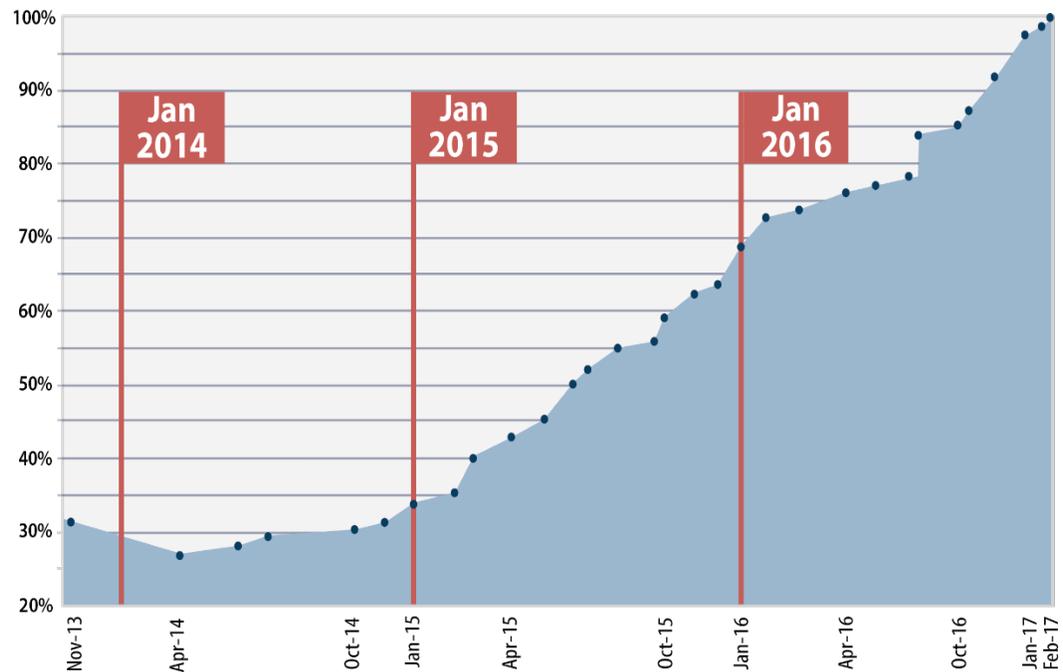
During the same timeframe of the 737 MAX 8 certification and the Lion Air accident, FAA and our office identified some significant concerns with FAA's ODA oversight, as well as with Boeing's ODA. In response to our 2015 report, FAA improved its ODA guidance in several areas but has not yet implemented a risk-based oversight approach. Additionally, FAA certification engineers continue to face challenges with balancing certification and oversight work. Finally, the Boeing ODA process and structure do not ensure ODA unit members are free from interference, thus leading to potential conflicting duties and undue pressure on ODA personnel.

FAA Has Not Implemented a Robust, Risk-Based Approach for ODA Oversight

Engineers in FAA's Boeing oversight office delegated a substantial amount of 737 MAX certification work to the Boeing ODA during the 2012–2017 certification process. Notably, the number of certification plans that FAA delegated increased significantly throughout the certification process, which, according to FAA managers, is typical as systems mature and the Agency gains confidence in Boeing's capabilities through its initial involvement. According to Boeing data, although FAA initially only delegated 32 percent (28 of 87) of the detailed certification plans to the Boeing ODA for approval, the Agency eventually delegated 87 percent (79 of 91) of the certification plans back to Boeing's ODA by November 2016 (see figure 9), including the flight controls and stabilizer plans containing MCAS.⁵⁴

⁵⁴ According to Boeing data. Additionally, between November 2016 and March 2017, FAA eventually delegated all 91 certification plans to Boeing's ODA.

Figure 9. Percentage of 737 MAX Certification Plans FAA Delegated to the Boeing ODA



Source: OIG analysis of Boeing data

Additionally, FAA can delegate specific deliverables within each certification plan, such as system safety assessments, even if FAA retains the plan itself. These delegations can also change over the course of the project, as was the case for the over 1,700 Boeing 737 MAX deliverables.

Since 2011,⁵⁵ our work has emphasized the importance of improving FAA’s oversight of ODA companies, including Boeing. For example, in October 2015,⁵⁶ we reported that FAA’s oversight of ODA program controls was not systems- and risk-based. Instead, FAA’s oversight was more focused on individual engineering projects and areas that we determined were low risk. FAA has since addressed most of our recommendations, including improving ODA guidance on oversight requirements, data analysis and sampling, use of self-audit data, resource sharing, and training. (See exhibit H for a list of selected OIG recommendations to FAA on ODA.)

⁵⁵ *FAA Needs To Strengthen Its Risk Assessment and Oversight Approach for Organization Designation Authorization and Risk-Based Resource Targeting Programs* (OIG Report No. AV2011136), June 29, 2011.

⁵⁶ *FAA Lacks an Effective Staffing Model and Risk-Based Oversight Process for Organization Designation Authorization* (OIG Report No. AV2016001), October 15, 2015.

However, more than 5 years after our recommendation, FAA has not yet implemented a risk-based approach to ODA oversight. This approach is intended to allow FAA to assess the greatest risks and target its oversight accordingly. The Agency has developed an update to its oversight process and guidance, but the update remains under internal review and coordination. FAA's current plan is to implement its new system for ODA oversight—via an update to ODA guidance—by July 2021. This new system will implement system-based evaluation criteria and risk-based tools to aid FAA team members in targeting their oversight. While this revised guidance will not contain changes specifically based on lessons learned from the 737 MAX accidents, the Agency stated it plans to incorporate some of these changes into the next formal revision or potentially sooner as an interim policy memorandum or notice.

In 2017, FAA tested the new risk-based system in a pilot program with ODAs in three companies. However, Boeing was not one of the companies included in the pilot program. The three ODA units participating in the pilot program each had approximately 40–50 unit members, whereas the Boeing ODA is 30 times larger, with approximately 1,500 unit members. Further, some current FAA employees identified potential problems with the applicability of this new guidance to the FAA office responsible for Boeing oversight and Boeing ODA. They are concerned that the new guidance would not work for a company like Boeing due to the volume and complexity of Boeing's operations. For example, in 2019 the Boeing ODA had five times as many major certification projects as the next largest ODA. (See exhibit I for a comparison of the Boeing ODA to other type certificate ODAs.) The planned guidance update contains a risk factor related to the number of unit members in establishing the minimum number of oversight activities for an ODA.

Furthermore, an important element of a risk-based oversight system is collecting and analyzing data in order to better target oversight. In 2015, we recommended that FAA provide guidance to certification personnel about performing ongoing data analysis. In response, FAA issued a 2016 policy memorandum that describes data sources that FAA oversight personnel should be aware of and consider in order to target oversight at high-risk activities. These data sources include the oversight office's own oversight records, as well as audit reports, annual ODA system evaluations, and ODA self-audits. However, our current review found that FAA's Boeing oversight office is not tracking oversight data (called supervision records), recurrent issues, or trends in a way that enables risk-based data analysis. For example, there is limited tracking of unsatisfactory supervision items that would indicate recurring issues, even though these items require corrective action plans from Boeing before they can be closed and resolved. As a result, FAA engineers may not have the risk-based data needed to focus their limited oversight resources on the most critical safety areas at the ODA.

FAA Engineers Continue To Face Challenges With Balancing Certification and Oversight Work

Our current review found that engineers in FAA's Boeing oversight office still face challenges in balancing certification and oversight responsibilities due to a persistent organizational culture driven by the demand to meet certification schedules and issues with prioritizing oversight, as well as Agency resource gaps. As a result, the office has struggled to complete its planned oversight of the Boeing ODA.

Persistent Cultural Issues and Focus on Manufacturer Certification Schedules Challenge FAA Oversight

FAA staff at the Boeing oversight office expressed concern that they did not have time to conduct oversight during the certification process. We reported in 2015 that oversight of ODA represents a major cultural shift in the way FAA engineers perform their work, moving from individual, project-based engineering work and a focus on assessing compliance of singular documents to a holistic approach assessing whether ODA companies have the systems in place to produce safe products.

Each FAA engineer assigned to a certification team is required to perform, at minimum, one ODA oversight activity annually, but it does not have to include each certification project. Based on discussions with FAA during our current review, we found that FAA's Boeing oversight office prioritizes performing certification work over ODA supervision activities. Many FAA staff we spoke with noted that ODA oversight did not receive the same level of priority as certification work. For example, one FAA Boeing oversight office employee indicated that Boeing is much more likely to make a phone call to FAA management regarding a certification document review than an oversight activity.

Further, on the 737 MAX, FAA's engineers performed only a small portion of their total oversight activities during the certification process. Our analysis of supervision records completed on the MAX showed that nearly 90 percent of documented oversight was performed *after* the aircraft received certification in March 2017 (see table 2).

Table 2. Annual FAA Boeing Oversight Office Supervision Records on the 737 MAX Certification Projects

Year	Satisfactory Result	Unsatisfactory Result	737 MAX Fleet Total Completed Supervision Records
2013	1 (100%)	0 (0%)	1
2014	1 (100%)	0 (0%)	1
2015	5 (71%)	2 (29%)	7
2016	20 (83%)	4 (17%)	24
January 1 – March 7, 2017	0 (0%)	1 (100%)	1
737 MAX 8 Certification – March 8, 2017			
March 8 – December 31, 2017	27 (49%)	28 (51%)	55
2018	57 (77%)	17 (23%)	74
2019	50 (69%)	22 (31%)	72
2020	34 (61%)	22 (39%)	56

34
Supervision Records on 737 MAX completed **during** certification process

257
Supervision Records on 737 MAX completed **after** certification process

Source: OIG analysis of FAA data

According to FAA guidance, FAA supervision and oversight of an ODA holder can occur at any point during the project. However, FAA Boeing oversight office engineers and specialists we interviewed held mixed opinions about when to perform oversight, as well as which FAA activities can be considered supervision. For example, while 7 of 12 representatives explicitly stated that oversight could be done at any point during or after a certification project, another 2 believed that most planned supervision should actually be performed after the certification project has been closed. FAA personnel at the Boeing oversight office recognize that engineers are not regularly documenting their in-process certification reviews as oversight, but believe they should be doing so.

In its response to the Official Report of the Special Committee on the FAA's Aircraft Certification Process, FAA noted the establishment of the Office of Aviation Safety ODA Office (as required by the FAA Reauthorization Act of

2018⁵⁷) to lead improvements in the ODA program, including consistent delegation decisions. The Agency is in the process of permanently staffing this office, and acknowledged changes are needed to enhance the oversight process and make the ODA program more effective. To that end, FAA plans to issue policy memos by March 2021 and an Order Revision by December 2021.

Resource Gaps Challenge FAA Engineers' Ability To Complete Required Supervision

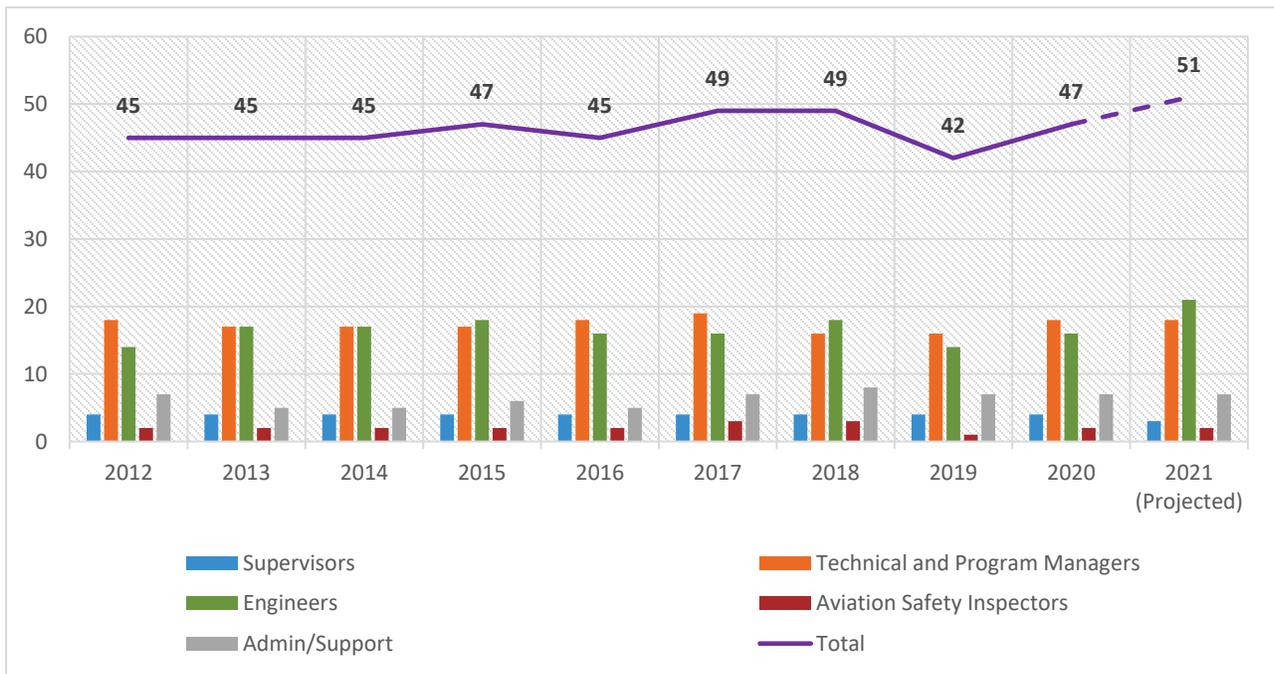
The FAA Boeing oversight office also faces challenges maintaining sufficient resources to complete oversight. For example, 15 of 24 (63 percent) FAA Boeing oversight office personnel we interviewed, including managers, expressed concerns with the current level of office staffing. In addition, interviewees stated that the office has experienced high levels of turnover and, as a result, lost valuable institutional knowledge and expertise. In particular, FAA representatives noted software engineers and systems analysis and human factors specialists as important positions that lacked sufficient staffing. These staffing issues may impact FAA's ability to robustly review submitted safety assessments, such as examinations of assumptions made and failure mode testing conducted by Boeing. For example, the FAA office responsible for certifying the 737 MAX currently uses a human factors expert from the Flight Test organization to provide expertise, and at the time of certification the office did not have a dedicated human factors expert⁵⁸ in that role. According to FAA, the Agency needs more systems engineers who can assess airplanes from a holistic perspective as aircraft become more technologically advanced.

We previously reported that FAA lacked a comprehensive process for determining staffing levels needed to provide ODA oversight. FAA officials stated that they established a process to ensure proper staffing by analyzing data and performance metrics. However, the Agency has not conducted a comprehensive assessment of staffing at FAA's Boeing oversight office, despite its unique role of overseeing the largest ODA and despite the fact that FAA has delegated an increasing percentage of certification plans and deliverables to the Boeing ODA over time. Staffing at FAA's Boeing oversight office remained relatively constant prior to the accidents (see figure 10), with total personnel numbers ranging between 45 and 49.

⁵⁷ Pub. L. 115-254, § 212 (October 5, 2018) (codified at 49 USC § 44736).

⁵⁸ According to FAA management, during the 737 MAX certification process, flight test engineers and pilots participated in and assessed human factors aspects but they were not specific human factors specialists.

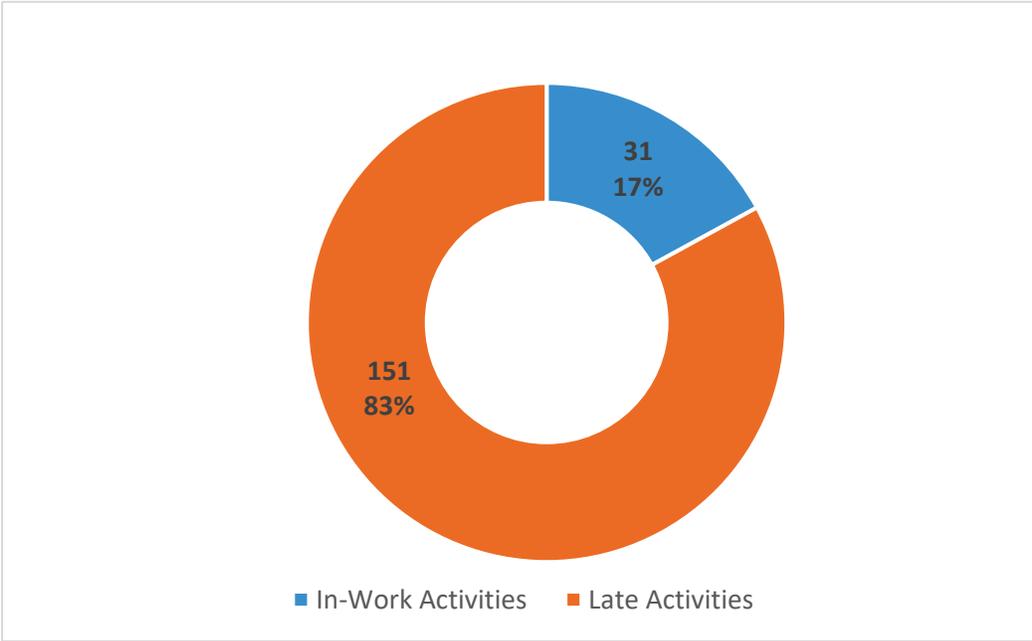
Figure 10. Boeing Oversight Office Staffing for All Aircraft Projects



Source: OIG analysis of FAA data

As a result of these issues, FAA was behind on its planned supervision activities. As of August 2020, FAA data showed that the FAA Boeing oversight office had 182 planned oversight activities, of which 151 (83 percent) were past due for completion (see figure 11), and 59 of those planned were over 430 days late. Planned oversight that FAA missed included ensuring that ODA unit members had sufficient authority to perform their authorized functions, had completed all required training, and were knowledgeable of current regulations and policies.

Figure 11. Snapshot of FAA’s Boeing Oversight Office Planned Supervision Activity Status, as of August 2020



Source: OIG analysis of FAA data

In October 2019, FAA’s Boeing oversight office management issued a nonconformance action for the office failing to complete planned fiscal year 2019 oversight and for not submitting fiscal year 2020 supervision plans on time. While we recognize the office has been challenged with additional duties as a result of the MAX accidents, FAA stated that limited resources and differing priorities across offices with shared oversight responsibility contributed to the nonconformance.⁵⁹ The manager of the FAA office’s Boeing oversight function initiated actions to resolve the issue, including developing new supervision plans for the current fiscal year. In addition, data show that FAA subsequently completed all required supervision records for 2020 as of September 30, 2020.

FAA is also planning actions to address its resource gaps. In its response to the Official Report of the Special Committee on the FAA’s Aircraft Certification Process, FAA stated its goal is to recruit, hire, maintain, and retain a workforce with technical expertise, capabilities, and adaptability required to continue to

⁵⁹ In the Nonconformity and Corrective Action, FAA management also noted that while they recognized the risk of the potential nonconformance before the end of the fiscal year, due to a focused effort on the 737 MAX return to service, they did not take action to prevent the nonconformance from occurring.

meet the safety needs of a rapidly-evolving aerospace system. The Agency states it will complete all of its planned actions by September 2021.

FAA's ODA Guidance Does Not Ensure ODA Unit Member or Overall Organizational Independence

We identified issues with the ODA structure that lead to potentially conflicting duties and undue pressure for ODA unit members. While we have not found any evidence of an inappropriately close relationship between FAA and Boeing to date, some FAA personnel we interviewed and responses to an internal survey indicated concern that FAA may be too deferential to industry. FAA took steps to resolve these issues at Boeing via a 2015 Settlement Agreement, but challenges remain.

FAA's ODA Program Does Not Prevent Conflicting Duties of ODA Unit Members

Regulations⁶⁰ require ODA companies to give unit members sufficient authority to perform their authorized functions, as well as to ensure no conflicting non-ODA duties or other interference affects unit member performance. In addition, FAA's ODA guidance⁶¹ states that a successful ODA ensures each unit member has enough authority and time to perform duties without pressure or influence from other parts of the organization, referred to as "undue pressure." FAA's guidance also states that unit members must not have conflicting restraints or responsibilities that conflict with those of the ODA unit. However, neither the regulations nor the guidance specifically define conflicting duties. Further, neither one specifically prohibit a company engineer from both demonstrating and then evaluating compliance on the same design.

Boeing's ODA has nearly 1,500 personnel acting on FAA's behalf; however, ODA unit member responsibilities may represent only a portion of an employee's duties, and staff are only considered ODA unit members when they are performing duties on FAA's behalf. We confirmed in interviews with FAA and Boeing ODA representatives that there were instances where the same company engineer worked on a particular design and then approved the design as an ODA unit member. This may not provide enough independence and could cause a conflict of duties for those unit members. According to the manager of the FAA oversight office, while FAA has verbally communicated concern about this

⁶⁰ 14 CFR § 183.57, Responsibilities of an ODA Holder.

⁶¹ FAA Order 8100.15B.

arrangement to Boeing, it is difficult to prevent it from occurring without an FAA policy disallowing the practice. According to Boeing ODA management, while a company best practice is to avoid overlap between duties, sometimes the overlap is necessary because of a lack of staff in certain technical areas.

We also identified FAA engineer concerns that Agency management can be too deferential to Boeing when delegating certain decisions back to the ODA. Some FAA staff cited instances in which they thought FAA managers shared their position during internal meetings, but made decisions in Boeing's favor after discussing with the company. For example, during MAX certification, six FAA technical specialists non-concurred on the design of the rudder cable, believing that it presented an unacceptable risk of being rendered inoperable during an uncontained engine failure.

A Safety Review Process Board consisting of FAA specialists agreed with the original non-concurring specialists.⁶² Although FAA management initially told Boeing in 1997 that it would have to address this issue for any aircraft beyond the 737 NG, FAA management ultimately agreed in 2016 with Boeing's position that the risk of failure was "extremely improbable." The design was ultimately delegated back to Boeing and approved, based on FAA management's reluctance to dictate a specific design change on a "proven system" that might have unintended safety consequences on another. In addition, according to FAA management, the regulatory requirement is to minimize the hazard of the failure, not to eliminate it, and this requires judgment as to what is needed for minimization.

The question of appropriate delegation within the ODA program has been raised at the national level as well. As indicated in the Agency's 2020 safety culture survey,⁶³ more than 40 percent of aviation safety staff who responded⁶⁴ did not feel FAA appropriately delegated certification activities to organizations and individual designees external to FAA. One common theme identified in survey responses was that FAA's Office of Aviation Safety management should "separate itself from the influences of industry, lobbyists, and other political pressures." Concerns included the organization's tendency to put profit over safety, external

⁶² In addition to performing its own initial review of the complaint, the Safety Review Process Board assigns a Subject Matter Expert Panel to investigate the report and provide recommendations to the Board. According to FAA management, in this case, the Panel included some of the same FAA employees who had made the original complaint.

⁶³ The MITRE Corporation, *Federal Aviation Administration (FAA) Aviation Safety Organization (AVS) Safety Culture Survey Findings*, February 28, 2020.

⁶⁴ MITRE administered the survey online to all 7,147 AVS employees and managers from November 20 to December 9, 2019. This was more than 6 months after the grounding of the Boeing 737 MAX. Staff from the FAA Aircraft Certification Service—responsible for aircraft certification and ODA oversight—represented 18 percent of total employees receiving the survey and had a 28 percent response rate (373 responses out of 1,311 total). This exceeded the overall response rate of 25 percent.

influence or “too close a relationship” with industry, and the handling of the 737 MAX. Further, the survey showed that external influence was an opportunity for improvement for all FAA Aviation Safety offices. While staff throughout FAA’s Aviation Safety organization had unfavorable opinions about external influence on the Agency, survey respondents from the aircraft certification service had the highest percentage of unfavorable responses (56 percent). FAA is planning to implement a confidential and non-punitive safety reporting system by June 2021 to help identify risks and improve the safety culture.

Preventing and Resolving Interference With ODA Unit Members Remains a Concern

FAA and ODA holders such as Boeing recognize the potential safety concerns that can stem from interference with ODA unit members. FAA requires⁶⁵ ODAs to establish—and include in their procedures manuals—processes for preventing interference, including performing periodic self-audits of the ODA unit members, processes, and compliance with FAA regulations and policy. Through such self-audits and other oversight activities, both the Boeing ODA and FAA have identified instances of potential undue pressure on unit members over the past 7 years.

During the same time period as the 737 MAX certification, two Boeing ODA self-audits—one in the Seattle, WA, area (2013) and another in Charleston, SC (2014)—identified employee concerns related to potential undue pressure within the ODA, although not specific to the 737 MAX 8. Additional self-audits between 2015 and 2017 also documented employee concerns on undue pressure.

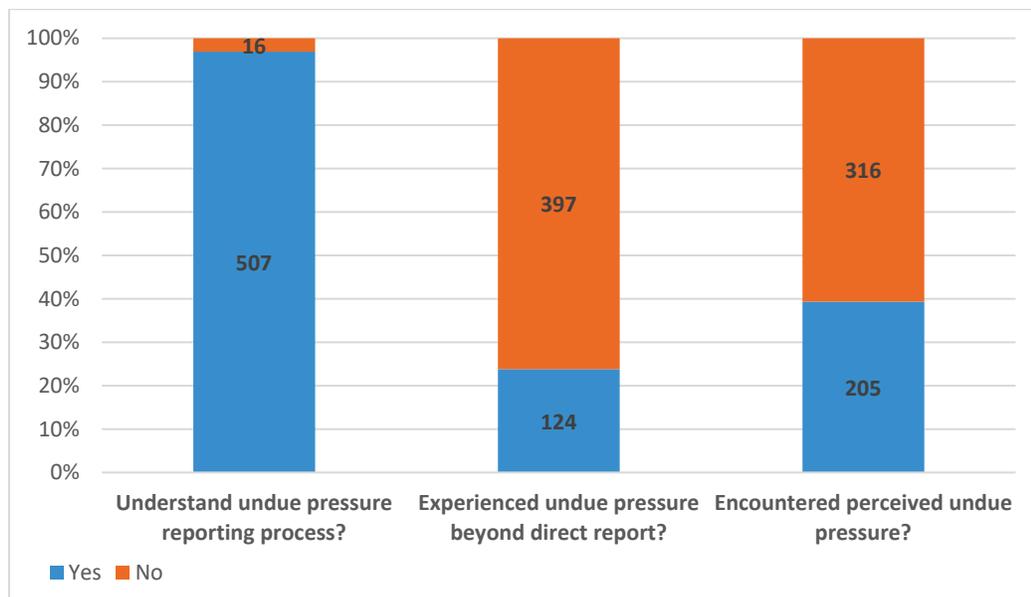
Further, over the course of 2018 and 2019, the Boeing ODA found concerns regarding undue pressure processes in four of seven internal audits conducted at selected Boeing facilities in Washington and South Carolina. While none of the audits found violations of FAA regulations and unit members expressed confidence in using the undue pressure reporting process, one audit noted a perception of “inadequate protection from actions by leadership outside of ODA.” Another internal audit noted a “general lack of confidence that the [undue pressure reporting] process would reach a satisfactory conclusion and/or protect the Unit Members.”

Additionally, in 2016, Boeing conducted an undue pressure survey of its ODA unit members. While 97 percent of the 523 respondents agreed that they understood the process for reporting undue pressure, almost 40 percent had encountered situations in which they perceived potential undue pressure, and almost a quarter

⁶⁵ 14 CFR § 183.53, Procedures manual and Order 8100.15B, Section 3-14.

had experienced undue pressure beyond their direct reporting structure while performing their ODA functions (see figure 12).

Figure 12. Results of Boeing's 2016 Survey on ODA Undue Pressure



Source: OIG analysis of Boeing data

Common themes in the survey responses included pressure from high workloads, confusion and potential undue pressure due to the dual roles of a unit member, and a desire for the company to share information about other undue pressure cases to help other unit members learn from them. For example, one respondent claimed that while "upper management will never issue a direct order for [a unit member] to do the wrong thing, [they] will create situations to indirectly pressure the [unit member] to do the wrong thing."

Following the 2016 survey, FAA found that all formally reported instances of undue pressure had been addressed by Boeing and did not necessitate immediate FAA action. However, according to the Agency, FAA observations indicated a need for further oversight of the undue pressure systems and processes.

Beginning in 2018, FAA took oversight actions related to alleged undue pressure, though not directly related to the 737 MAX. For example, FAA initiated a formal compliance action⁶⁶ against Boeing in November 2018, citing five engineering unit members that had conveyed instances of interference or conflicting duties

⁶⁶ In contrast to a legal enforcement action, such as a civil penalty, compliance actions allow a manufacturer to address a noncompliance in accordance with a corrective action plan agreed upon with FAA. According to FAA, an insufficient response to a compliance action can result in enforcement action.

with their unit member roles. In subsequent months, Boeing requested three extensions from FAA before providing its response to the compliance action, including a corrective action plan on September 19, 2019. FAA did not accept Boeing’s response to this compliance action. Further, FAA also issued two separate letters of investigation⁶⁷ in June 2019 and March 2020 against Boeing’s South Carolina production facility, related to potential undue pressure of inspection unit members. FAA did not accept Boeing’s response to the June 2019 letter of investigation, or Boeing’s response to the more recent March 2020 letter. In August 2020, FAA proposed two civil penalties against Boeing totaling \$1.25 million for the allegations cited in the June 2019 and March 2020 letters, detailing work interference and undue pressure of ODA unit members by Boeing management (see table 3).

Table 3. Recent FAA Compliance and Enforcement Actions on Boeing ODA

Boeing Location	Year	Noncompliance Issues	Outcome
Seattle: Formal Compliance Action <i>(Engineering Unit Members)</i>	Nov 2018	Reported instances of direct interference from Boeing or conflicting duties with unit member roles	Boeing submitted a corrective action plan (months late, after multiple extensions) that FAA rejected.
South Carolina: Letter of Investigation <i>(Inspection Unit Members)</i>	June 2019	Reported instances of management interference and issues with the ODA organizational structure	Boeing submitted corrective action plan that FAA rejected; FAA Proposed Civil Penalty.
South Carolina: Letter of Investigation <i>(Inspection Unit Members)</i>	March 2020	Reported instances of interference/undue pressure and acceptance of supplier work not following quality system processes	FAA rejected Boeing’s response; FAA Proposed Civil Penalty.

Source: OIG analysis of FAA and Boeing data

Results from another survey of unit members initiated by Boeing in December 2019 show that issues with undue pressure and the culture at Boeing remain, noting that 40 percent of respondents had perceived undue pressure directed at themselves or another unit member in the preceding 24 months. While the causes of undue pressure on an ODA unit member can vary, Boeing’s 2016 internal survey results and formal responses to FAA’s enforcement actions suggest that schedule pressure (which arises due to cost concerns) is a dominant

⁶⁷ A Letter of Investigation, as part of FAA compliance and enforcement program, serves the dual purposes of notifying an apparent violator that they are under investigation for a potential violation and providing the factual details about the activities being investigated. It also gives the apparent violator an opportunity to provide input and respond to the Agency. According to FAA, an insufficient response to a Letter of Investigation can result in enforcement action.

factor leading to undue pressure. Other potential causal issues noted include: Boeing management lacking an understanding of their ODA roles; lack of communication between unit members and ODA management; and mistrust of the ODA resolution process.

In addition, FAA has highlighted concerns with the delineation of company and ODA roles at Boeing, as the ODA leadership also holds concurrent leadership roles within the company. As a result, Boeing ODA unit members may feel pressure to approve items or affirm compliance with regulations without sufficient time to perform a review or against their own judgment and expertise. This pressure could potentially impact aircraft safety and ultimately the flying public. FAA is currently considering updating its ODA guidance on interference and pressure so that companies include procedures or systems necessary to ensure that no conflicting non-ODA unit duties or other interference affects performance of authorized functions, in order to demonstrate compliance to the regulations.⁶⁸ In response to concerns from FAA and the internal surveys, Boeing has shared additional leadership communications on the importance of a culture of compliance, implemented a new anonymous safety reporting website, and deployed additional undue pressure training.

Despite a 2015 Settlement Agreement, FAA Remains Challenged To Monitor Overall Boeing ODA Performance

FAA and Boeing signed a Settlement Agreement in December 2015, wherein Boeing agreed to take actions in specified regulatory compliance areas and acknowledged obligations to meet engineering and manufacturing performance metrics. These actions would resolve allegations documented in 13 FAA Enforcement Investigative Reports spanning from 2009 through 2015. These reports cited violations of Boeing's approved production, delegation, and certification systems.

Although not specifically tied to the 737 MAX 8 aircraft, the issues covered by the agreement pertained to the quality of ODA certification documents and Boeing's processes to identify and resolve the root causes of identified problems.⁶⁹ For example, Boeing was required to improve the percentage of certification plans and other documents submitted to FAA that are "first-pass quality" annually from 2016 through the end of the Agreement.⁷⁰ Upon signing the agreement, Boeing

⁶⁸ 14 CFR §183.57(c).

⁶⁹ Root causes are the contributory or initiating underlying causal factors of a nonconformity, noncompliance, or undesirable event. A causal factor is considered the root cause if its removal from the event sequence prevents the undesirable event from recurring.

⁷⁰ One performance metric example required 75 percent of Boeing certification plans to be "first-pass quality" when submitted to FAA in 2016, and increased the requirement to 85 percent by 2020.

paid a \$12 million civil penalty to FAA and could face civil penalties up to \$24 million if it fails to meet the settlement commitments by December 31, 2020.

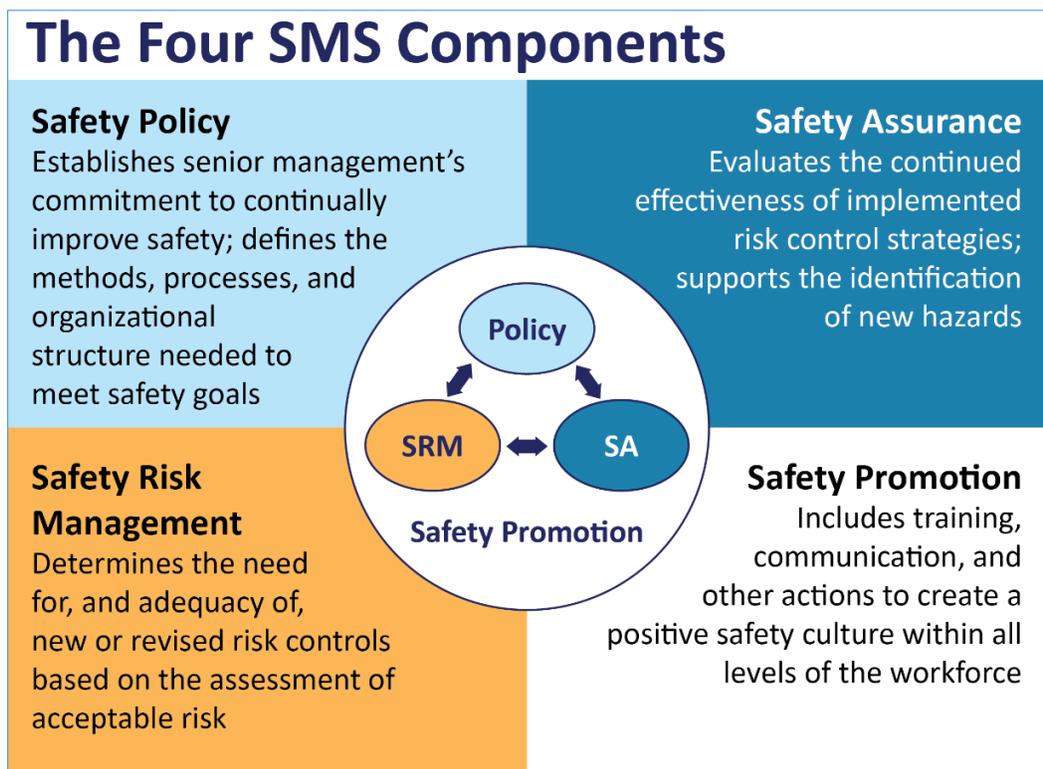
Between February 2017 and June 2020, FAA completed 24 ODA oversight activities⁷¹ related to the compliance findings in the 2015 Settlement Agreement. FAA deemed 6 of the 24 (25 percent) activities to be unsatisfactory, related to incomplete information and/or insufficient justification provided in certification project documentation.

According to FAA and Boeing officials, the company is still working on improving its documentation and processes, particularly in the area of identifying and resolving root causes to prevent non-conformances and non-compliances from recurring. Although the deadline for the agreement was at the end of 2020, FAA has not yet determined if Boeing has fulfilled all of its obligations under the settlement agreement or if the agreement will be extended.

The overall purpose of the settlement agreement was to steer Boeing to more of a Safety Management System (SMS). Although Boeing included an SMS plan as part of the settlement agreement, current FAA regulations do not require manufacturers to have an SMS in place. Such systems are required for Part 121 airplane operators and are designed to demonstrate a company's ability to manage risk before an event occurs, as outlined in figure 13.

⁷¹ FAA ODA oversight employees actually initiated 31 of these supervision records, but 5 of those records were deleted by FAA management after preliminary review. Of the 26 remaining records, 14 were completed, 4 records were still in progress, 6 unsatisfactory records were awaiting corrective action from Boeing, and 2 new records had not yet received preliminary management review as of June 15, 2020.

Figure 13. Overview of a Safety Management System (SMS)



Source: FAA

Although not required for manufacturers, FAA has been encouraging Boeing to develop an SMS for its design certification. Boeing has hired a new senior executive to lead its SMS development efforts and is working with FAA to gain approval for its new system.

The Special Committee on the FAA's Aircraft Certification Process recommended in its January 2020 report that FAA mandate manufacturers implement SMS to help create a connection to the SMS of other aviation entities, such as airlines, as well as support manufacturers' effective safety performance. In its response, FAA stated it is initiating rulemaking to mandate SMS for key aviation sectors, including design and manufacturing organizations, and that until the rulemaking is complete, the Agency will continue to promote voluntary adoption of SMS in these types of organizations. FAA officials stated that they anticipate publishing the Notice of Proposed Rulemaking for SMS by September 2022.

Conclusion

For decades, FAA has maintained an admirable safety record. However, the lessons of the Boeing 737 MAX demonstrate the need for a more holistic approach to both certification and FAA's safety oversight of manufacturers. To its credit, FAA is taking significant action to correct identified weaknesses. Yet, our review identified numerous oversight issues in areas ranging from the Agency's guidance for FAA certification engineers to resource gaps and concerns of undue pressure at Boeing's ODA, among others. Much work remains to address weaknesses in FAA's certification guidance and processes and to improve its communication with manufacturers and within the Agency. In addition, FAA has not yet taken sufficient steps to ensure it best targets its ODA oversight to the highest-risk areas. These actions will be vital to restore confidence in FAA's certification process and ensure the highest level of safety in future certification efforts of major passenger aircraft.

Recommendations

To improve FAA's certification and ODA oversight processes, we recommend that the Federal Aviation Administrator:

1. Update the Changed Product Rule to address the integration of technological advances and exceptions.
2. Evaluate criteria for determining whether a system meets the definition of a "novel or unusual design feature," add specificity, and implement identified improvements.
3. Require applicants to submit failure probability analysis and key assumptions in certification deliverables.
4. Assess and update Advisory Circular 25.1309 guidance related to engineering assumptions regarding pilot actions, pilot reaction times, and failure mode testing.
5. Establish and implement processes for manufacturers to officially notify FAA certification engineers of any changes made to System Safety Assessments, including after FAA flight testing has begun.
6. Establish and implement communication and coordination procedures between Boeing and FAA, and within FAA among flight test, certification, and Flight Standards.

7. Establish and implement policies and procedures for the Aircraft Evaluation Group related to its role in the certification process that require, at a minimum: formal documentation of approvals; documentation of operational flight test parameters, procedures, and outcomes; expanded written guidance on the FSB process; and improved consistency of procedures between AEG offices.
8. Incorporate lessons learned from the Boeing 737 MAX accidents into the ODA oversight process guidance implementing a risk-based approach.
9. Clarify priorities, roles, and responsibilities for FAA engineers regarding oversight and certification work, including the timing of when oversight should be performed.
10. Perform a workforce assessment at FAA's Boeing Aviation Safety Oversight office to determine engineer resource and expertise needs, particularly in the areas of systems engineering, human factors, and software development, to both perform certification and oversight work, and take action as necessary.
11. Conduct an assessment to determine how frequently unit members serve as both the company engineer involved in a design as the applicant and also find compliance on FAA's behalf on that same design. Based on the results of this assessment, revise ODA guidance to strengthen controls in this area.
12. Revise ODA program requirements to ensure ODAs have internal controls in place and are organized in a way that prevents interference with ODA unit members.
13. Determine if Boeing has met the requirements of the 2015 Settlement Agreement, including reporting metrics, given the deadline of December 31, 2020, and take further actions as necessary.
14. Complete the ongoing rulemaking project that proposes requiring manufacturers to implement Safety Management Systems, including setting and publishing expected timeframes.

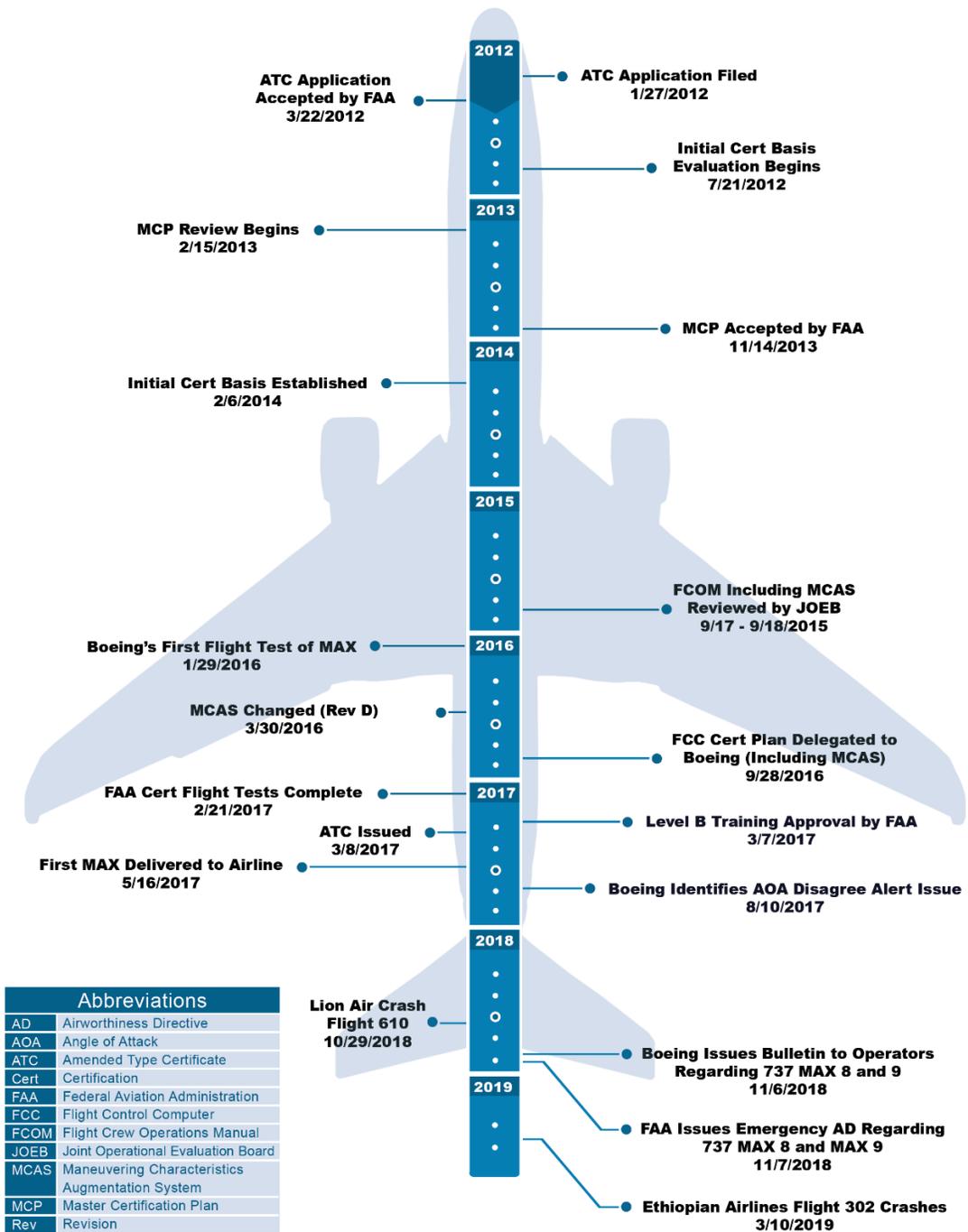
Agency Comments and OIG Response

We provided FAA with our draft report on December 9, 2020, and received its response on January 25, 2021, which is included as an appendix to this report. FAA concurred with all 14 recommendations and provided appropriate actions and planned completion dates. Accordingly, we consider all recommendations resolved but open pending completion of the planned actions.

Actions Required

We consider all 14 recommendations resolved but open pending completion of the planned actions.

Exhibit A. Timeline of Major Events for the Certification of the Boeing 737 MAX 8



Source: OIG analysis of FAA and Boeing data

Exhibit B. Scope and Methodology

We conducted this performance audit between April 2019 and December 2020 in accordance with generally accepted Government auditing standards as prescribed by the Comptroller General of the United States. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We determined that the data we used was sufficiently reliable for audit purposes, based on our: review of FAA and third party documentation; interviews with knowledgeable agency officials; direct tests of electronic FAA data sources; use of corroborating evidence; and reviews of various FAA system documents and summary reports. As such, we believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

This report is in response to requests from the Secretary and members of Congress to determine and evaluate FAA's process for certifying the Boeing 737 MAX series of aircraft. This is our second report on FAA's certification of the 737 MAX and follows our first report, issued June 29, 2020.

To determine the reliability of the data, we compared dates regarding Boeing 737 MAX certification documentation received from both FAA and Boeing and obtained source documentation to confirm and resolve discrepancies from respective presentations. We also sought and obtained source documentation to verify information obtained from testimonial evidence. In addition, we assessed the completeness and integrity of FAA's ODA oversight records by reviewing the content and accuracy of the data and determining FAA's processes for assessing data quality.

To obtain detailed, factual information regarding FAA's aircraft certification process and the historical certification of Boeing's 737 MAX, we met with FAA aircraft certification officials in both Washington, DC, and Oklahoma City, OK, to discuss the evolution of FAA's certification and ODA policies and guidance. We collected current and historical ODA policy and guidance documents and internal policy office analyses, including data tracking metrics for Boeing's ODA. We also collected and analyzed FAA organizational charts and staffing data. In addition, for comparison purposes we collected and analyzed data on the size and volume of work completed by eight other Type Certificate ODAs and their respective FAA oversight offices.

We received multiple briefings from FAA's Aircraft Certification Service, System Oversight Division and Compliance and Airworthiness Division, as well as the Flight Standards Service, Aircraft Evaluation Group, located at the Northwest Mountain Regional Office. In addition, we conducted interviews of FAA safety

inspectors; flight test and control engineers; standards staff engineers; and certification, oversight, and flight test management personnel. Specifically, we interviewed 36 individual FAA staff who were either involved in the 737 MAX certification process or oversight of Boeing's ODA, or who worked in FAA branches, offices, or positions with directly related roles or subject matter expertise. These 36 consisted of: 12 supervisors, program managers, inspectors, and engineers who were in the FAA Boeing oversight office as of March 2019; and 24 personnel from other key offices: the Seattle AEG, Seattle Aircraft Certification Office, Northwest Mountain Region Flight Test, and the Transport Standards Branch. In addition, we interviewed four FAA managers in charge of specific Agency improvement initiatives related to the 737 MAX accidents and representatives from two FAA offices in charge of certification and ODA policy.

We reviewed and analyzed certification plans and associated deliverables, issue papers, internal correspondence, internal safety analyses conducted during the certification process and following the 2018 and 2019 accidents, and flight test documents pertaining to the Boeing 737 MAX. We also interviewed a National Air Traffic Controllers Association (NATCA) representative for FAA aircraft certification engineers to look at issues raised over the course of the MAX's certification.

We analyzed the 2015 Settlement Agreement between FAA and Boeing and collected, reviewed, and analyzed supervisory records, internal office oversight tools, ODA audits, and compliance and enforcement actions that FAA initiated on Boeing during the timeframe of the MAX's certification. We also collected information related to recent compliance actions regarding undue pressure of Boeing ODA employees.

We visited Boeing facilities in Everett, Renton, and Seattle, WA, and interviewed Boeing management about the Boeing 737 MAX's certification. We collected further documentation from Boeing regarding certification plans, internal system safety analyses, MCAS-specific requirements and testing documents, internal flight test reports, and updates regarding return-to-service actions and MCAS software revisions. We also interviewed ODA management and collected and reviewed internal ODA procedure manuals and self-audits. Interviews of Boeing certification personnel were limited in scope because of liability concerns raised by Boeing. Individual interviews of Boeing ODA staff to obtain information about undue pressure and other climate issues were conducted within agreed-upon parameters with Boeing, such as OIG not asking the two ODA staff interviewed about specific certification decisions or certification programs such as the 737 MAX.

We also reviewed multiple, independent Boeing 737 MAX certification process reports that contain recommendations for FAA. These reports include the Department's Special Committee to Review the FAA's Aircraft Certification

Process and FAA’s formal response; the National Transportation Safety Board (NTSB)’s Safety Recommendation Report; the Joint Authority Technical Review (JATR)’s Observations, Findings, and Recommendations; Indonesia’s National Transportation Safety Committee Accident Report; and Ethiopia’s Ministry of Transport Aircraft Accident Investigation Bureau Preliminary and Interim Reports. Additionally, we conducted interviews with FAA representatives leading several special projects and initiatives started in response to these reports, including SMS, certification process improvements, and FAA communication.

Exhibit C. Organizations Visited or Contacted

Federal Aviation Administration

Aircraft Certification Service:

System Oversight Division

Boeing Aviation Safety Oversight Office, Des Moines, WA

Boeing Certificate Management Office, Des Moines, WA

Compliance and Airworthiness Division

Northwest Flight Test Section, Des Moines, WA

Seattle Aircraft Certification Office, Des Moines, WA

Policy and Innovation Division

Transport Standards Branch – Des Moines, WA

Certification Procedures Branch – Washington DC

Delegation and Organizational Procedures Branch – Oklahoma City, OK

Flight Standards Service (AFX):

Seattle Aircraft Evaluation Group, Des Moines, WA

Other Organizations

Boeing Commercial Airplanes

Everett, WA

Renton, WA

Seattle, WA

National Air Traffic Controllers Association

National Transportation Safety Board

Exhibit D. Glossary of Terms

Term		Definition
AC	Advisory Circular	Guidance documents produced by FAA to inform and guide entities within the aviation industry, as well as the general public, and describe actions or advice that FAA expects to be implemented or followed.
AD	Airworthiness Directive	Legally enforceable rules issued by FAA to correct an unsafe condition in a product. 14 CFR Part 39 defines a product as an aircraft, aircraft engine, propeller, or appliance.
AEG	Aircraft Evaluation Group	A group in FAA's Flight Standards Service tasked with determining the appropriate types of training for aircraft that are undergoing evaluation for an ATC.
AOA	Angle of Attack	The difference between the pitch angle (nose direction) of the airplane and the angle of the oncoming wind. AOA sensors measure the angle between an airplane's wing and the oncoming air.
ATC	Amended Type Certificate	An ATC is issued by FAA when the holder of a type certificate receives FAA approval to modify an aircraft design from its original design. An ATC approves not only the modification but also how that modification affects the original design.
EASA	European Aviation Safety Agency	The Agency responsible for standardization and oversight for all aviation safety certification activities of its Member States, as well as approval of aircraft design organizations world-wide and approval of production and maintenance organizations outside the European Union. EASA develops common safety rules at the European level, and monitors the implementation of standards through inspections and coordination with the national authorities of its member states.
FAA	Federal Aviation Administration	The Agency responsible for overseeing numerous aviation activities designed to ensure the safety of the flying public.
FCC	Flight Control Computer	The component of digital flight control software that provides several functions integral to flight, including autopilot, flight director, and speed trim.
FCOM	Flight Crew Operations Manual	Contains operations information and provides the necessary operating limitations, procedures, performance, and systems information the flight crew needs to safely and efficiently operate the aircraft.
FSB	Flight Standardization Board	FAA typically establishes an FSB when certificating large jet or propeller aircraft. One of the FSB's mandates is to develop training objectives for normal and emergency procedures and maneuvers.

Term		Definition
JATR	Joint Authorities Technical Review	A team consisting of representatives of regulators from 10 civil aviation authorities that was chartered by FAA on June 1, 2019, to examine the Agency's certification of the 737 MAX 8. The JATR issued a report on October 11, 2019.
JOEB	Joint Operational Evaluation Board	A multi-regulatory body that conducts a multi-day session with global regulatory and airline pilots to validate training requirements.
MCAS	Maneuvering Characteristics Augmentation System	Flight control law implemented on the 737 MAX to improve aircraft handling characteristics and decrease pitch-up tendency at elevated angles of attack.
NTSB	National Transportation Safety Board	Conducts independent accident investigations, advocates safety improvements, and decides pilots' and mariners' certification appeals.
ODA	Organization Designation Authorization	FAA created the ODA program in 2005 to standardize its oversight of organizational designees (e.g., aircraft manufacturers) that have been approved to perform certain functions on the Agency's behalf, such as determining compliance with aircraft certification regulations.
SMS	Safety Management Systems	A safety promotion program that manages safety risk and assures the effectiveness of safety risk controls. It includes systematic procedures, practices, and policies for the management of safety risk.
TC	Type Certificate	An approval document issued by FAA that states a specific aircraft model is compliant with airworthiness regulations.

Exhibit E. Background on MCAS

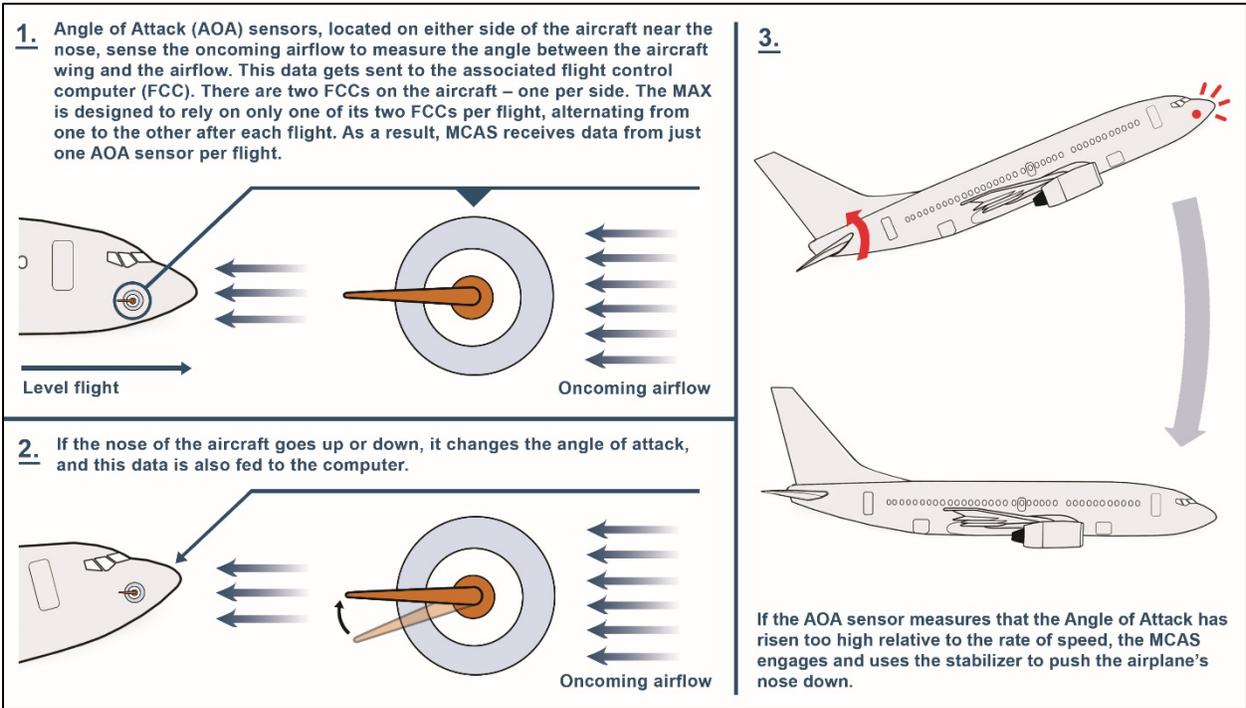
Engine Size and Placement: 737 NG (pictured left) vs. 737 MAX (pictured right)



Boeing developed MCAS for the 737 MAX 8 to compensate for changes in aerodynamics from the previous model caused by the MAX's larger engines and the placement of those engines on the wing.

Source: Boeing

How MCAS Works on the 737 MAX



Source: OIG analysis of FAA and Boeing data

Exhibit F. Selected Recommendations to FAA and Actions in Response to the Special Committee

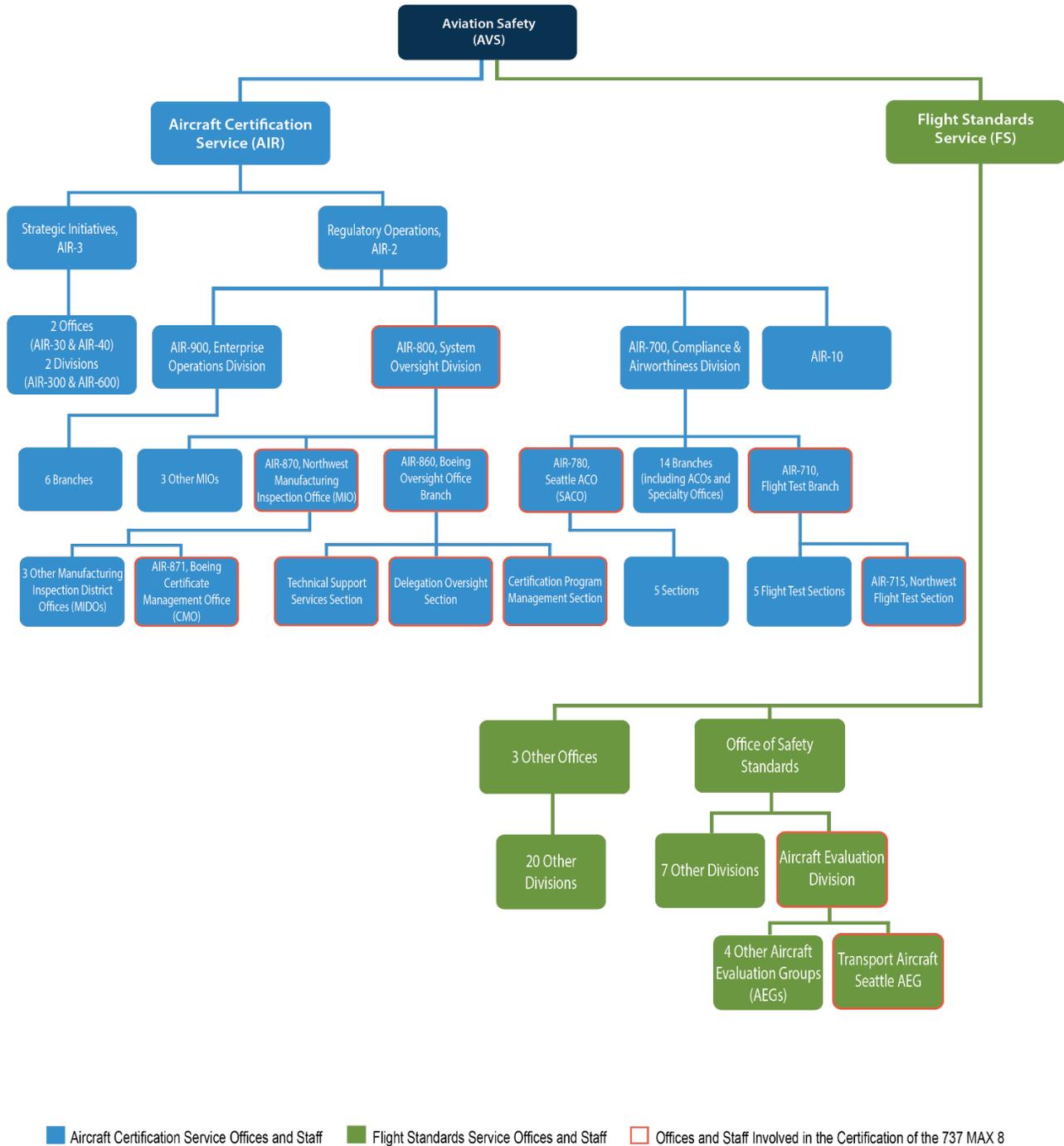
Topic	Selected Committee Recommendations*	FAA Actions	Milestone
Amended Type Certificates	Update guidance to include cross-system evaluation of changes and vulnerabilities that can develop with multiple updates; as well as clarify roles and responsibilities in assessing what constitutes a significant change.	<ul style="list-style-type: none"> • Create a consensus-based set of recommendations for implementation by FAA and other stakeholders to address regulatory and/or policy gaps associated with changed products. 	<ul style="list-style-type: none"> • Re-chartered the Certification Management Team as of November 30, 2020; FAA plans to hold the first meeting in February 2021.
Systems Safety	Enhance standards to ensure that systematic human factor analyses are conducted for all safety critical functions and failure modes.	<ul style="list-style-type: none"> • Incorporate new rules, policy and associated training to better integrate human factors-related evaluation and system safety assessment methodologies. 	<ul style="list-style-type: none"> • Launched a policy review team in June 2020. • Publish a Notice of Proposed Rulemaking (NPRM) by August 2021 related to system safety assessments.
FAA Internal Coordination	Review and clarify the roles and responsibilities of the Aircraft Evaluation Group.	<ul style="list-style-type: none"> • Reinforce established expectations and adopt new norms while improving early Aircraft Certification and Flight Standards engagement. • Clarify roles and responsibilities between Aircraft Certification and Flight Standards. 	<ul style="list-style-type: none"> • Issued a memo to the workforce in June 2020 to reinforce expectations. • Identify ways to improve collaboration and increase integration by the end of fiscal year 2020; issue policy changes by the end of 2021.
Personnel	Re-evaluate its workforce strategy to ensure it is sufficient.	<ul style="list-style-type: none"> • Define workforce needs for FAA to fulfill its safety responsibilities (including ODA oversight) without incurring undue delays for industry and deliver improved training. 	<ul style="list-style-type: none"> • Complete all actions by September 2021.
Delegation	Address concerns about potential undue pressure on an ODA Unit and provide guidance on how and when FAA technical specialists and ODA unit members communicate directly regarding technical concerns.	<ul style="list-style-type: none"> • Use the new ODA Office to implement a consistent ODA program strategy. • Proactively address undue pressure; and promote understanding of undue pressure and actions to take if it occurs. • Clarify communication expectations between FAA and ODA personnel. 	<ul style="list-style-type: none"> • Issue policy memos by March 2021; revise the Order by December 2021.
SMS	Mandate implementation of SMS for design and manufacturing organizations.	<ul style="list-style-type: none"> • Implement scalable SMS and continue to promote voluntary adoption of SMS. 	<ul style="list-style-type: none"> • NPRM by September 2022.

* FAA's response covers all recommendations received from the Special Committee and other groups.

Source: OIG analysis of FAA data. See: [Response to Official Report of the Special Committee on the Federal Aviation Administration's Aircraft Certification Process. Aviation Safety April 2020 Final Report.](#)

Exhibit F. Selected Recommendations and Actions in Response to the Special Committee

Exhibit G. FAA's Aviation Safety Group Offices Involved in Certification of the 737 MAX Aircraft—Organizational Structure (2017–Present)



Source: OIG analysis of FAA data

Exhibit H. Selected OIG Recommendations to FAA on ODA Improvements

IG Report	OIG Recommendation	Recommendation Status	FAA Action to Resolve
2011, Rec #5	<p>Improve the new oversight structure for large ODA holders by:</p> <p>a) Developing training for FAA engineers and disseminating comprehensive procedures on the new oversight structure for large ODA holders; and</p> <p>b) Assessing the effectiveness of the new oversight structure before implementing it at other large ODA holders.</p>	Closed	<p>FAA concurred with a) and completed training in January 2012; FAA also updated its procedures in the ODA order.</p> <p>FAA concurred with b) and assessed the effectiveness of the new oversight structure in May 2013.</p>
2015, Rec #3	Develop and implement system-based evaluation criteria and risk-based tools to aid ODA team members in targeting their oversight.	<i>Open, Pending FAA Completion of Planned Actions</i>	<p>FAA concurred and performed a pilot program in 2017 with three companies to operate under new draft ODA procedures. The risk-based ODA oversight approach for all ODA holders was planned for the end of FY 2018, but FAA needed to do more internal coordination. This ODA Procedures revision is still in draft.</p> <p><i>Target Date: July 2021.</i></p>
2015, Rec #4	Clarify guidance to ODA oversight staff on the minimum oversight requirements for each oversight team member.	Closed	FAA concurred and clarified its guidance.
2015, Rec #5	Provide guidance on data that ODA team members should be analyzing on an ongoing basis, enhance its national summary of biennial audit results to include more specificity, and disseminate it to ODA teams to use in planning their oversight.	Closed	FAA concurred and provided guidance on data analyses.
2015, Rec #7	Provide guidance on the level of sampling required to achieve effective oversight of ODA company personnel performing key aircraft certification functions, and issue sampling guidance to field offices.	Closed	FAA concurred and issued sampling guidance to field offices.

Source: OIG analysis of FAA data. See: OIG Report Nos. AV2011136 (2011) and AV2016001 (2015). OIG reports are available on our website at <http://www.oig.dot.gov/>.

Exhibit I. Comparison of FAA ODA Oversight Offices for Type Certificate ODA Companies

Oversight Office/Company	2019 Total ODA Major Certification Projects	Average Annual FAA Supervision Records	FAA Core OMT Staff	ODA Personnel
Boeing	448	359	42	1,500
Gulfstream	89	38	19	477
Textron (prev. Cessna)	26	48	11	404
Bell Helicopter	10	30	16	137
Sikorsky	18	25	19	85
Learjet	9	18	10	74
GE	35	7	7	73
Piper	5	8	9	51
Cirrus	4	7	11	42

Source: OIG analysis of FAA data

Exhibit J. Major Contributors to This Report

ROBIN KOCH	PROGRAM DIRECTOR
MARSHALL JACKSON	PROGRAM DIRECTOR
STEFANIE MCCANS	PROJECT MANAGER
CHRISTOPHER FRANK	PROJECT MANAGER
ANDREW FARNSWORTH	SENIOR ANALYST
AIESHA MCKENZIE	SENIOR ANALYST
KEVIN MONTGOMERY	SENIOR ANALYST
RACHEL MENCIAS	AUDITOR
GRACE ITA-CICCHELLI	ANALYST
SETH KAUFMAN	DEPUTY CHIEF COUNSEL
AUDRE AZUOLAS	SENIOR TECHNICAL WRITER
SHAWN SALES	VISUAL COMMUNICATIONS SPECIALIST
ANGELICA PEREZ	VISUAL COMMUNICATIONS SPECIALIST

Appendix. Agency Comments



Federal Aviation Administration

Memorandum

Date: January 25, 2021

To: Matthew E. Hampton, Assistant Inspector General for Aviation Audits

From: H. Clayton Foushee, Director, Office of Audit and Evaluation, AAE-1

Subject: Management Response to Office of Inspector General (OIG) Draft Report Oversight of Boeing 737 MAX Certification by the Federal Aviation Administration (FAA)

A handwritten signature in blue ink, appearing to read "Clay Foushee", is written over the "To:" and "From:" lines of the memorandum.

Safety is the Department of Transportation's (DOT) top priority and the Federal Aviation Administration (FAA) is committed to continuous improvement of aviation safety. The FAA concurs with OIG's recommendations, many of which align closely with those of other reviews and experts, including the Secretary's Special Committee to Review FAA's Aircraft Certification Process. Since the two tragic Boeing 737 MAX accidents, FAA has already made substantial progress towards implementing reforms that address some of your recommendations. OIG's thorough review and thoughtful recommendations will inform that work, bolstering FAA's certification and oversight programs and improving aviation safety.

Updating FAA Guidance and Addressing Gaps in Communication

FAA is taking numerous steps to reform its certification process, including the changed product rule, and to update its guidance to ensure a more holistic assessment of aircraft design changes. To address any regulatory or policy gaps related to the certification of changed products, FAA is chartering a team with representation from other civil aviation authorities to evaluate certification requirements for derivative aircraft, thus ensuring a consistent worldwide approach to safety and the similar evaluation and treatment of design changes. FAA also is focused on developing appropriate guidance, standards, and regulations to support the introduction of new technology into the aviation market. Throughout this process, FAA will maintain engagement with its international partners to ensure continued global harmonization of aircraft certification. Working on aircraft certification matters with our international partners does take time, as such efforts can require rulemaking and coordination not only in the United States, but also across foreign regulatory frameworks to achieve and maintain harmonization.

In addition, FAA is adjusting its processes to improve the flow of information during the certification process. For example, FAA is encouraging manufacturers to engage FAA earlier in their development process to provide the agency a better understanding of novel features and

new technology, and to give companies an understanding of how FAA will approach them during certification. FAA also is evaluating how system safety assessments are conducted and is implementing changes to ensure the development of data, as well as its use, can effectively inform the certification and entry into service of new or modified products.

Finally, FAA is addressing both procedural and cultural barriers to improve coordination between the Aircraft Certification Service (AIR) and Flight Standards Service (FS) throughout the lifecycle of a certification project—from application through entry into service. FAA has already launched a joint Integrated Program Management project to review interfaces between AIR and FS, and to update related policy and guidance as necessary. More direct leadership engagement, establishment of expectations, and increased clarity of roles to encourage cross- function communication will facilitate this goal. Furthermore, the designation of AIR and FS project managers will enhance cross-office awareness and further integrate decision-making.

Strengthening Oversight of Organization Designation Authorization (ODA) Programs

FAA has established and is currently working to operationalize fully the ODA Office to improve performance in the ODA program. The ODA Office will promote consistency in delegation decisions and in FAA’s oversight of ODAs. The ODA Office also will serve as a source of information and education to combat undue pressure within ODAs, provide clarification for expectations regarding communications between ODA personnel and FAA, and address instances of undue pressure on ODA personnel at a systemic level. To institutionalize and document these improvements, FAA is in the process of developing enhanced guidance on undue pressure and communications for future publication.

Other Recommendations

FAA agrees that Safety Management Systems (SMS) increase safety and promote an effective oversight process. Currently, FAA is drafting a rulemaking to require SMS for design and manufacturing organizations (RIN: 2120-AL60, Safety Management System (SMS) for Parts 21, 91, 135, and 145). SMS for these organizations will help ensure a holistic, proactive assessment of whether the combination of design, procedures, and training will support effective safety performance. FAA strongly promoted voluntary SMS for design and manufacturing organizations, and will continue to do so while the rulemaking is in progress.

FAA also recognizes the need to recruit, to hire, and to retain a skilled workforce with the technical expertise and abilities required to ensure safety in a rapidly evolving aerospace system. This includes expertise in applied math, human factors, international safety standards, software engineering, and systems engineering. Currently, FAA is working to understand and manage its personnel requirements, and to influence cultural changes in the workforce to reflect better the changing nature of the aviation industry and the evolution of aircraft design. FAA is committed to incorporating lessons learned from our ongoing experiences with the complex aviation environment as we consider our future workforce needs.

With regard to the 2015 Settlement Agreement with Boeing, FAA is in the process of closing that settlement. The process of closing the settlement includes evaluating whether Boeing met the requirements of the Settlement Agreement.

Conclusion

FAA leadership appreciates OIG’s work. The Department’s top priority is safety, and FAA is committed to continuous improvement. Your report will further inform FAA’s efforts to advance aviation safety in the United States and throughout the global aerospace system. Based on our review of OIG’s draft report, the FAA concurs with the recommendations and plans to complete actions to implement the recommendations as noted below. While FAA anticipates completing intermediate steps for many of these recommendations in advance of the Target Action Dates, some recommendations may require regulatory action to implement and the Target Action Dates are calculated accordingly.

Recommendations	Target Action Dates
13	March 31, 2021
3, 12	May 31, 2025
2	December 31, 2025
8, 9, 10	December 31, 2022
6, 7, 11	December 31, 2023
14	March 20, 2024
1, 4, 5	December 31, 2025

We appreciate this opportunity to respond to the draft report, and we look forward to the results of the OIG’s continued review, including its planned report on the continued operational safety process related to the 737 MAX.

U.S. DOT IG Fraud & Safety Hotline

hotline@oig.dot.gov | (800) 424-9071

<https://www.oig.dot.gov/hotline>

Our Mission

OIG conducts audits and investigations on behalf of the American public to improve the performance and integrity of DOT's programs to ensure a safe, efficient, and effective national transportation system.

OFFICE OF INSPECTOR GENERAL
U.S. Department of Transportation
1200 New Jersey Ave SE
Washington, DC 20590



www.oig.dot.gov