United States Government Accountability Office

Report to Congressional Committees

August 2020

AIRCRAFT NOISE

Information on a Potential Mandated Transition to Quieter Airplanes

Accessible Version

GAO-20-661

GAO Highlights

Highlights of GAO-20-661, a report to congressional committees

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Why GAO Did This Study

Although advances in technology have led to quieter aircraft capable of meeting increasingly stringent noise standards, airport noise remains a concern. FAA regulates aircraft noise by ensuring compliance with relevant noise standards. In 1990, federal law required large jet airplanes to comply with stage 3 noise standards by 1999, leading to a phase-out of the noisiest airplanes (stage 1 and 2 airplanes). Later, federal law required smaller airplanes to comply with stage 3 standards by 2016.

The FAA Reauthorization Act of 2018 included a provision for GAO to review a potential phase-out of stage 3 airplanes—the loudest aircraft currently operating in the United States. This report describes (1) the proportion of stage 3 airplanes in the U.S. fleet, and what proportion of these stage 3 airplanes are able to meet more stringent noise standards and (2) selected stakeholders' views on the potential benefits, costs, and challenges of phasing out stage 3 airplanes.

GAO reviewed FAA's analysis of December 2017 fleet data, analyzed January 2020 fleet data from select airlines and airframe and engine manufacturers, and interviewed FAA officials. GAO also interviewed a non-generalizable sample of 35 stakeholders, including airlines; airframe and engine manufacturers; airports; and industry associations, selected based on fleet and noise data, stakeholder recommendations, or prior GAO knowledge.

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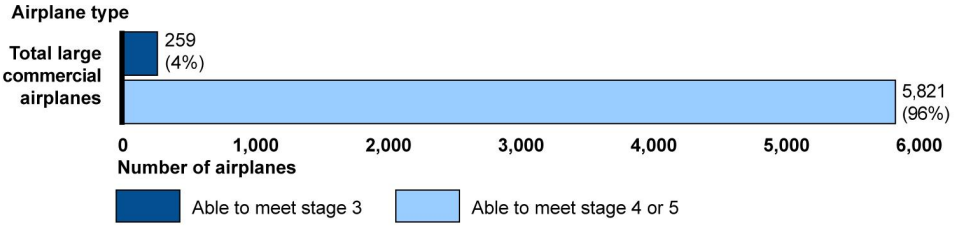
What GAO Found

Based on Federal Aviation Administration (FAA) data and GAO estimates, most U.S. large commercial jet airplanes are certificated at the minimum required stage 3 noise standards, but nearly all of them are able to meet more stringent noise standards. Sixty-three percent of large commercial airplanes in the United States are certificated as meeting the stage 3 standards; however, 87 percent of them were manufactured with technologies that are able to meet more recent and stringent stage 4 or 5 standards as currently configured, according to FAA's 2017 analysis. By analyzing updated data from airlines and aviation manufacturers, GAO estimated that this proportion is even higher: 96 percent of large commercial airplanes are able to meet stage 4 or 5 standards (see figure). According to FAA officials and aviation stakeholders, the primary reason many large commercial airplanes certificated as stage 3 produce lower than stage 3 noise levels is because engine and airframe technology has outpaced the implementation of noise standards. More recently, some airlines have accelerated retirement of certain airplanes, some of which are certificated as stage 3, due to the decrease in travel amid the COVID-19 pandemic. For the generally smaller regional commercial jets (i.e., generally with less than 90 seats), 86 percent are able to meet stage 4 or stage 5 standards, according to manufacturers' data. With regard to general aviation (which are used for personal or corporate flights), 73 percent of the jet airplanes in that fleet are able to meet the more stringent stage 4 or 5 standards, according to manufacturers' data.

GAO Estimate of The Number of Large Airplanes in the U.S. Commercial Fleet That Are Able to Meet Stage 3 or Stage 4 and 5 Noise Standards, January 2020



Source: GAO assessment of December 2017 Federal Aviation Administration (FAA) noise-based fleet composition analysis and January 2020 aviation stakeholder data. | GAO-20-661

Data table for GAO Estimate of The Number of Large Airplanes in the U.S. Commercial Fleet That Are Able to Meet Stage 3 or Stage 4 and 5 Noise Standards, January 2020

Airplane type	Number able to meet stage 3	Percentage able to meet stage 3	Number able to meet stage 4 and 5	Percentage able to meet stage 4 and 5
Large commercial airplanes	259	4	5821	96

According to stakeholders GAO interviewed, a phase-out of jet airplanes that are certificated as meeting stage 3 standards would provide limited noise reduction and limited other benefits, and could be costly and present other challenges. A phase-out could require recertificating the vast majority of stage 3 airplanes to comply with stage 4 or 5 standards. This process could be costly for operators and manufacturers but would provide little reduction in noise. Further, airplanes currently unable to meet more stringent standards would require modifications or

face retirement. For older airplanes that could not be recertificated to meet stage 4 or 5 standards, some operators could incur costs for replacement airplanes sooner than originally planned. Although stakeholders indicated that a phase-out would not substantially reduce noise, they identified other limited benefits newer airplanes generate, such as reduced greenhouse gas emissions and fuel consumption.

Contents

Tables

Figures

Abbreviations

Balanced Approach	Balanced Approach to Aircraft Noise Management
COVID-19	Coronavirus Disease 2019
DOT	Department of Transportation
EPNL	effective perceived noise level
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
MD-80	McDonnell Douglas MD-80 (aircraft)
MTOW	maximum takeoff weight
NPIAS	National Plan of Integrated Airport Systems
RAA	Regional Airline Association

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August 20, 2020

The Honorable Roger Wicker
Chairman
The Honorable Maria Cantwell
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Peter DeFazio
Chairman
The Honorable Sam Graves
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

Although advances in technology have led to increasingly quieter airplanes, demands for quieter skies persist. Despite the recent reduction in domestic and international flights resulting from the Coronavirus Disease 2019 (COVID-19) pandemic, aircraft noise has been one of the top environmental issues at airports across the country, generating concerns within many surrounding communities.[1] One way the Department of Transportation's (DOT) Federal Aviation Administration (FAA) has worked to address these concerns is through the application of aircraft noise standards. FAA implemented its first noise standards in 1969 and since then has adopted increasingly stringent (i.e., quieter) standards.[2] FAA classifies airplanes that meet the various noise

[1]For more information on environmental concerns at U.S. airports, see FAA, *FAA Strategic Plan FY 2019-2022 (Washington, D.C.: 2019) and* GAO, *Airport Noise Grants: FAA Needs to Better Ensure Project Eligibility and Improve Strategic Goal and Performance Measures*, GAO-12-890 (Washington, D.C.: Sept. 12, 2012), For an indication of how aircraft noise is generating concerns, see one list of the numerous lawsuits against FAA regarding aviation noise. Airport Noise Law, *Litigation News*, accessed August 7, 2020, http://airportnoiselaw.org/lit-idx.html.

[2]FAA's first noise regulations were promulgated in 14 C.F.R. Part 36 on December 1, 1969.

standards into 5 stages:[3] Airplanes classified as stages 1 and 2 (the noisiest aircraft) have been prohibited by regulation and federal law respectively from operating in the United States.[4] Airplanes operating today in the United States—classified as stages 3, 4, or 5—are much quieter. Nevertheless, concerns about aircraft noise continue to result in noise-related complaints.

In light of the federal prohibitions on the operations of stage 1 and 2 airplanes, which significantly reduced airplane noise, the FAA Reauthorization Act of 2018 included a provision for GAO to examine whether the government should phase out stage 3 airplanes that are not capable of meeting the stage 4 noise levels.[5] This report examines:

- the proportion of stage 3 airplanes in the U.S. fleet, including which proportion of these stage 3 airplanes are able to meet more stringent noise standards, and
- selected stakeholders' perspectives on the potential benefits, costs, and challenges of phasing out stage 3 airplanes.

For both objectives, we reviewed laws, regulations, and relevant literature, including our prior work, focused on airplane noise ratings and certifications.[6] We also reviewed FAA reports and other documents, such as the advisory circulars that identify airplane noise ratings and provide

[3]Although jet and non-jet airplanes and other aircraft are subject to noise standards, this report focuses only on U.S.-registered and operated jet airplanes. Therefore, our use of the term "airplane" denotes only civil subsonic jet airplanes. A jet-powered airplane is an aircraft powered by a turbojet or turbofan engine. We use the term "aircraft" when referring to FAA oversight because FAA oversees many other types of aircraft in addition to jet airplanes.

[4]This applies to the contiguous United States and the District of Columbia. Stage 1 airplanes were prohibited from operating after January 1, 1985. Large stage 2 airplanes were prohibited from operating as of January 1, 2000, and small stage 2 airplanes were prohibited from operating after January 1, 2016. We last reported on this topic—focusing on the phase-out of large stage 2 airplanes—in September 2001. GAO, *Aviation and the Environment: Transition to Quieter Aircraft Occurred as Planned, but Concerns About Noise Persist*, GAO-01-1053 (Washington, D.C.: Sept. 28, 2001).

[5]Pub. L. No. 115-254, § 186, 132 Stat. 3186, 3234-35.

[6]For example, we reviewed GAO-01-1053 and *Aviation Noise: Costs of Phasing Out Noisy Aircraft*, GAO/RCED-91-128 (Washington, D.C.: July 2, 1991); the FAA Reauthorization Act of 2018 and the Airport Noise and Capacity Act of 1990, Pub. L. No. 101-508; §§ 9301-09, 104 Stat. 1388, 1388-378 to 1388-384; and 14 C.F.R. Part 36 and 14 C.F.R. Part 161.

guidance on FAA's recertification process. Furthermore, we interviewed officials in the FAA Office of Environment and Energy, Aircraft Certification Service, and Office of the Chief Counsel.

To address our first objective, we reviewed FAA's analysis of December 2017 data on stage 3 airplanes in the U.S.-registered in-service fleet, which examined the extent to which airplanes certificated as stage 3 could meet stage 4 or stage 5 noise standards.[7] For each U.S.-based in-service airplane, FAA's analysis identified its noise stage level based on both the certificated stage level and the estimated stage level that an airplane of its model is capable of meeting, based on available noise data. To calculate the noise stage that an airplane is capable of meeting, FAA compared the current certificated noise margin data to stage level standards. This distinction between an airplane's certificated stage level and the stage level it is able to meet is important because some airplanes are certificated as stage 3 but are capable of meeting more stringent noise standards.[8]

To obtain the most recent information possible, we requested and obtained fleet statistics from selected airlines and selected airframe manufacturers (our selection criteria are described below). These airlines and airframe manufacturers provided fleet data as of January 2020. These data included documentation from the airlines about the number of certificated stage 3 airplanes in their fleets and information regarding how many of these stage 3 airplanes are capable of meeting more stringent noise standards. We also analyzed Regional Airline Association (RAA) fleet data published in its *2019 Annual Report*.[9] This allowed us to corroborate FAA's 2017 analysis and to identify more recent information

[7]DOT's Volpe National Transportation Systems Center conducted the fleet composition analysis at the request of FAA, and it represents FAA's most recent analysis of stage levels for the U.S.-based fleet. Considering that commercial airplanes generally have life spans of 25 to 40 years, FAA's 2017 analysis includes most of the airplanes in today's fleet. For the remainder of the report, this analysis of December 2017 U.S.-based in-service airplane fleet will be referred to as FAA's 2017 analysis or FAA's analysis. When referencing data from FAA's analysis, we refer to the information as FAA's 2017 data.

[8]Many airplane models are certificated at one noise stage level but are sometimes manufactured to meet more stringent noise levels. This is because when airplane models go through the certification process prior to operation, they are certificated based on the noise standards in place at that time. Although an airplane model may meet more stringent (i.e., quieter) noise standards that are later developed, each individual airplane maintains its original certificated noise rating unless it is recertificated to the newer standards. We discuss this issue in more detail later in this report.

[9]RAA, *Creating Connection: Annual Report 2019* (Washington, D.C.).

that informs the noise level for selected airplane fleets. To determine age-related information for the U.S.-based passenger and cargo airline fleets, we obtained these data from Diio, a private company that provides online access to U.S. airline fleet and other data with a query-based user interface.

We assessed the reliability of the data provided by FAA, Diio, and selected airlines and manufacturers by reviewing them for anomalies, outliers, or missing information, among other things. We also interviewed officials from FAA, DOT's Volpe National Transportation Systems Center, and selected airlines, which included asking any questions we had about the data based on our review. We found these data sufficiently reliable for capturing fleet composition and noise information. For the Diio dataset, we reviewed the relevant documentation of the dataset and previous GAO reports that used Diio data and found the dataset sufficiently reliable for identifying the ages of airplanes in the passenger and cargo airline fleets.

To address our second objective, we interviewed representatives from nine commercial airplane, general aviation, and engine manufacturers;[10] ten domestic passenger and cargo airlines;[11] and three airports.[12] We also interviewed one nationwide community noise group and twelve associations representing a cross-section of the aviation industry.[13] These interviewees were selected on the basis of industry recommendations, data on airlines' fleet sizes and compositions, data on airport operations

[10]We interviewed the following airframe manufacturers: Boeing (large airplanes); Bombardier and Embraer (regional airplanes); and Dassault, Gulfstream, and Textron (small airplanes). Airbus declined to participate in an interview for this study. In addition, we interviewed the following engine manufacturers: GE Aviation, Pratt & Whitney, and Rolls Royce.

[11]We interviewed the following airlines: Allegiant, American, Compass, Delta, Envoy, FedEx, Republic, SkyWest, Southwest, and United.

[12]We interviewed officials at Minneapolis-St. Paul International, Seattle-Tacoma International, and Teterboro airports.

[13]We interviewed the following nationwide community noise group and industry associations: the Aeronautical Repair Station Association, Aerospace Industries Association, Aircraft Owners and Pilots Association, Airlines for America, Airports Council International-North America, American Association of Airport Executives, Cargo Airline Association, General Aviation Manufacturers Association, National Air Cargo Association, National Air Transport Association, National Business Aviation Association, National Organization to Insure a Sound Controlled Environment, and Regional Airline Association.

and passengers, research, and our past work on the stage 2 phase-out.[14] The information we obtained from these interviews cannot be generalized beyond those we interviewed. We did not conduct a benefit-cost analysis for a potential stage 3 phase-out because a phase-out could be structured in different ways, and without parameters for a phase-out, aviation stakeholders were unable to identify specific costs and benefits of transitioning from stage 3 aircraft. However, this report provides perspectives on potential benefits, costs, and challenges of phasing out stage 3 airplanes from across a diverse set of stakeholders.

We used a standard set of questions to interview each of the 35 selected stakeholders to ensure we consistently captured their views on various aspects of our objective. We then analyzed the results of these interviews to identify the main themes and develop summary findings. To characterize aviation stakeholders' views throughout this report, we defined modifiers (e.g., "most") to quantify stakeholders' views as follows:

- *"nearly all"* stakeholders represents 31 to 35 stakeholders,
- *"most"* stakeholders represents 23 to 30 stakeholders,
- *"many"* stakeholders represents 16 to 22 stakeholders,
- *"several"* stakeholders represents 9 to 15 stakeholders, and
- *"some"* stakeholders represents 3 to 8 stakeholders.

We conducted this performance audit from May 2019 to August 2020 in accordance with generally accepted government auditing standards. 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 believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[14]GAO-01-1053.

Background

The U.S. Aviation Industry

The U.S. aviation industry includes, among other entities, network (or legacy), low-cost, and regional passenger airlines; cargo airlines; charter and on-demand passenger operators; and the general aviation community.[15] All of them operate airplanes of various sizes. Most of the network airlines operate complex hub-and-spoke systems and contract with regional airlines—which generally use smaller airplanes with fewer than 90 seats—to feed regional passenger traffic into those hubs.[16] Together with cargo and low-cost airlines they operated nearly 7,100 airplanes as of 2017.[17] According to FAA's 2018 General Aviation Survey, there are approximately 15,000 general aviation jet airplanes. They range in size from large passenger airplanes (e.g., the Boeing 757) to very small airplanes (e.g., the Eclipse 550, which seats 6). The engines and airframes are the primary sources of airplane noise.

The life spans of airplanes are dependent on several factors, such as the number of take-offs and landings performed and maintenance and operating costs. Commercial passenger and cargo airplanes generally have life spans of 25 to 40 years. Airplanes used for scheduled passenger service likely have the highest utilization rates because they only earn revenue when in operation. Cargo airlines often purchase former passenger airplanes for their operations, further lengthening the life spans of these airplanes. General aviation airplanes could have considerably longer life spans because they may be operated only a few times monthly or annually. Airlines and other operators devise their fleet

[15]General aviation includes non-commercial operations that range from flights for personal pleasure to worldwide corporate flights.

[16]Some regional airlines are subject to scope clauses, which are part of the contract between a major airline and the trade union of its pilots that limits the number and size of aircraft that may be flown by the airline's regional airline affiliate.

[17]FAA, *FAA Aerospace Forecast: Fiscal Year 2020-2040* (Washington, D.C.: March 2020). During the writing of this report, many U.S. airlines had taken large percentages of their aircraft out of service because of the significant drop in demand as a result of the COVID-19 pandemic. In addition, some regional airlines have gone out of business. Therefore, the number of in-service airplanes referenced in our analyses does not reflect the current situation.

plans and make airplane purchases partially on the basis of these lifespan assumptions.

Airports are the typical focal point for aviation noise. Jet airplanes provide service to approximately 960 of the 3,321 airports included in the National Plan of Integrated Airport Systems (NPIAS).[18] FAA identifies 380 airports in the NPIAS as being primary airports, which receive scheduled air service and have 10,000 or more enplaned passengers per year.[19] According to FAA, primary airports account for 99 percent of passenger enplanements and 36 percent of aircraft operations. The nearly 3,000 non-primary airports include general aviation airports, which do not have scheduled service or have less than 2,500 annual passenger enplanements, and reliever airports, which are general aviation airports that are designated by FAA to relieve congestion at nearby commercial service airports. In 2012, according to FAA, 40 NPIAS airports—primarily the largest and busiest airports in the country—accounted for 85 percent of the nationwide 55 decibel Day-Night Average Sound Level population exposure attributable to large stage 3 jets.[20] The airports for this analysis were selected from the more than 600 airports in the NPIAS that had at least one average daily jet departure.

Noise Standards

Airplanes that operate in the United States must meet noise standards mandated by FAA.[21] FAA first developed noise standards in 1969. Since 1971, the International Civil Aviation Organization (ICAO), in conjunction with FAA and other national aviation agencies, has developed noise

[18]FAA, Report to Congress: National Plan of Integrated Airport Systems (NPIAS) 2019-2023 (Washington, D.C.: September 2018).The NPIAS contains existing and proposed airports that are included in the national airport system, the roles they currently serve, and the amounts and types of airport development eligible for federal funding.

[19]An enplanement is a person boarding an aircraft in the United States in scheduled or nonscheduled service in intrastate, interstate, or foreign air transportation.

[20]FAA, *Evaluating Noise Reductions from a Theoretical Phase-Out of Stage Three Aircraft* (Washington, D.C.: February 2016). This report used 2012 airport noise data. Day-Night Average Sound Level means the 24-hour average sound level, in decibels, for the period from midnight to midnight, obtained after the addition of ten decibels to sound levels for the periods between midnight and 7 a.m., and between 10 p.m., and midnight, local time.

[21]14 C.F.R. Part 36.

standards.[22] In order to harmonize federal law with these standards, Congress may pass conforming legislation and FAA amends its regulations, as applicable. Airplane noise standards establish the noise limits that airplanes are permitted to generate in takeoff, landing, and "sideline (lateral) measurements."[23] The noise measurement level is defined in terms of the "effective perceived noise level (EPNL)," which takes into account the duration of the noise event.[24]

FAA defines five stages of airplanes based on their noise levels. In a 1975 regulation, FAA defined stages 1, 2, and 3.[25] The same regulation also required applicants for new type certificates, applied for on or after November 5, 1975 and before January 1, 2006, to comply with stage 3 noise limits, which were stricter than the noise limits in effect at that time. Later, two additional stages (stages 4 and 5) were added as a result of FAA harmonizing new ICAO noise standards with U.S. regulations. Additional details about FAA's role in implementing noise standards are discussed in the next section.

Airplanes are certificated to the noise standards that were in effect at the time of the type certificate application.[26] The oldest noise standards under

[22] ICAO is a United Nations specialized agency, established by member states (countries) in 1944 to reach consensus on international civil aviation standards and recommended practices and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

[23]The "sideline (lateral) noise measurement" is defined as the point on a line parallel to and 1,476 feet from the runway center line, where the noise level is at maximum during take-off.

[24]The basic element for noise certification criteria is the noise evaluation measure known as effective perceived noise level, EPNL, in units of effective perceived noise in decibels, which is a single number evaluator of the subjective effects of airplane noise on human beings. EPNL consists of instantaneous perceived noise level, corrected for spectral irregularities, and for duration. The spectral irregularity correction, called "tone correction factor," is made at each time increment for only the maximum tone. 14 C.F.R. § A36.4.1.1 of Appendix A of Part 36.

[25]14 C.F.R. § 36.1(f), While in the United States noise standards are referred to as "stages," ICAO refers to them by the chapter of the ICAO Annex 16, Volume I, where international noise standards appear. Therefore, ICAO's chapter 3 is equivalent to U.S. stage 3, and ICAO's chapter 14 is equivalent to U.S. stage 5. Unless otherwise noted, we refer to the standards as "stages."

[26]FAA issues type certificates as part of a certification process when a manufacturer presents a design of an aircraft and all component parts (including propellers, engines, control stations, etc.). It signifies the design is in compliance with applicable airworthiness, noise, fuel venting, and exhaust emissions standards.

which U.S. airplanes currently are certificated are stage 3, as stage 1 and 2 airplanes have been prohibited from operating in the United States. However, some airplanes are certificated at stage 4 and at stage 5. The stage 3 standards for takeoff, landing, and sideline measurements range from 89 to 106 decibels, depending on the airplane's weight and number of engines. The stage 4 and 5 standards are increasingly stringent (i.e., requiring that airplanes emit lower decibels) as they require noise level measurements that are lower than stage 3 requirements.[27] Therefore, the stage 4 requirement represents a cumulative decrease of 10 decibels from the stage 3 standard, and the stage 5 requirement represents a cumulative decrease of 7 decibels from the stage 4 requirements.[28]

Today, airplanes may be manufactured and certificated to stage 3, 4, or 5 noise standards. However, according to FAA regulations, new large airplane types must be designed to meet stage 5 noise standards. Since there are many versions, airframe/engine combinations, and owners of each airplane type, not all airplanes of each type can be assumed to be certificated at the same noise level. For example, although the Boeing 737 Classic was initially manufactured in 1991 and certificated at stage 3, later versions are certificated as stage 4.[29] Table 1 lists each noise stage, its applicability, and examples of airplanes certificated at each stage.

[27]By comparison, a food blender makes about 88 decibels of noise, while a rock band playing indoors makes about 108 to 114 decibels of noise.

[28]The margin of individual measuring points must at least equal stage 3 standards for stage 4 airplanes and not less than 1 decibel below stage 3 standards for stage 5 airplanes. Additionally, for stage 4 airplanes, the combination of any two measuring points must have a margin of not less than 2 decibels below stage 3 standards.

[29]Current noise certification regulations do not include standards for supersonic airplanes other than the Concorde. In its 2018 reauthorization, FAA was directed to exercise leadership in the creation of federal and international policies, regulations, and standards relating to the certification and the safe and efficient operation of civil supersonic aircraft. FAA Reauthorization Act of 2018. Sec. 181 of Pub. L. No. 115-254, 132 Stat. 3186, 3230. In April 2020, FAA issued a Notice of Proposed Rulemaking with a 3-month comment period that would govern maximum takeoff and landing noise levels for next-generation supersonic aircraft with a maximum take-off weight of 150,000 pounds and a maximum operating cruise speed of up to Mach 1.8 (approximately 1,381 miles per hour). 85 Fed. Reg. 20431 (Apr. 13, 2020).

Table 1: Noise Certification Stages for U.S.-Registered Airplanes

Stage	Effective date of legislation or final rule[a]	Applicability/deadline	Airplane example	Date U.S. operations prohibited
1	October 13, 1977	Applies to airplanes certificated[b] before 1969 that do not meet the 1969 noise standards	Douglas DC-8	January 1, 1985
2	October 13, 1977	Applies to airplanes that meet the 1969 noise standards	Boeing 727-100	January 1, 2000 for airplanes weighing more than 75,000 lbs.
2	October 13, 1977	Applies to airplanes that meet the 1969 noise standards	Gulfstream G-II	January 1, 2016 for airplanes weighing 75,000 lbs. or less
3	October 13, 1977	Applies to applicants for new type certificates applied for on or after November 5, 1975	McDonnell Douglas MD-80	N/A
4	August 4, 2005	Applies to applications for new airplane type designs on and after January 1, 2006	Boeing 737-400	N/A
5	November 3, 2017	Applies to new airplane type designs with a maximum takeoff weight (MTOW) of 121,254 lbs. or more on or after December 31, 2017	Airbus A380	N/A
5	November 3, 2017	Applies to new airplane type designs with an MTOW of less than 121,254 lbs. on or after December 31, 2020	Gulfstream G500	N/A

Source: GAO analysis of Federal Aviation Administration (FAA) and Gulfstream information. | GAO-20-661

[a]In 1973, FAA amended its regulations to apply the noise standards to all newly manufactured aircraft, no matter when the aircraft were designed.

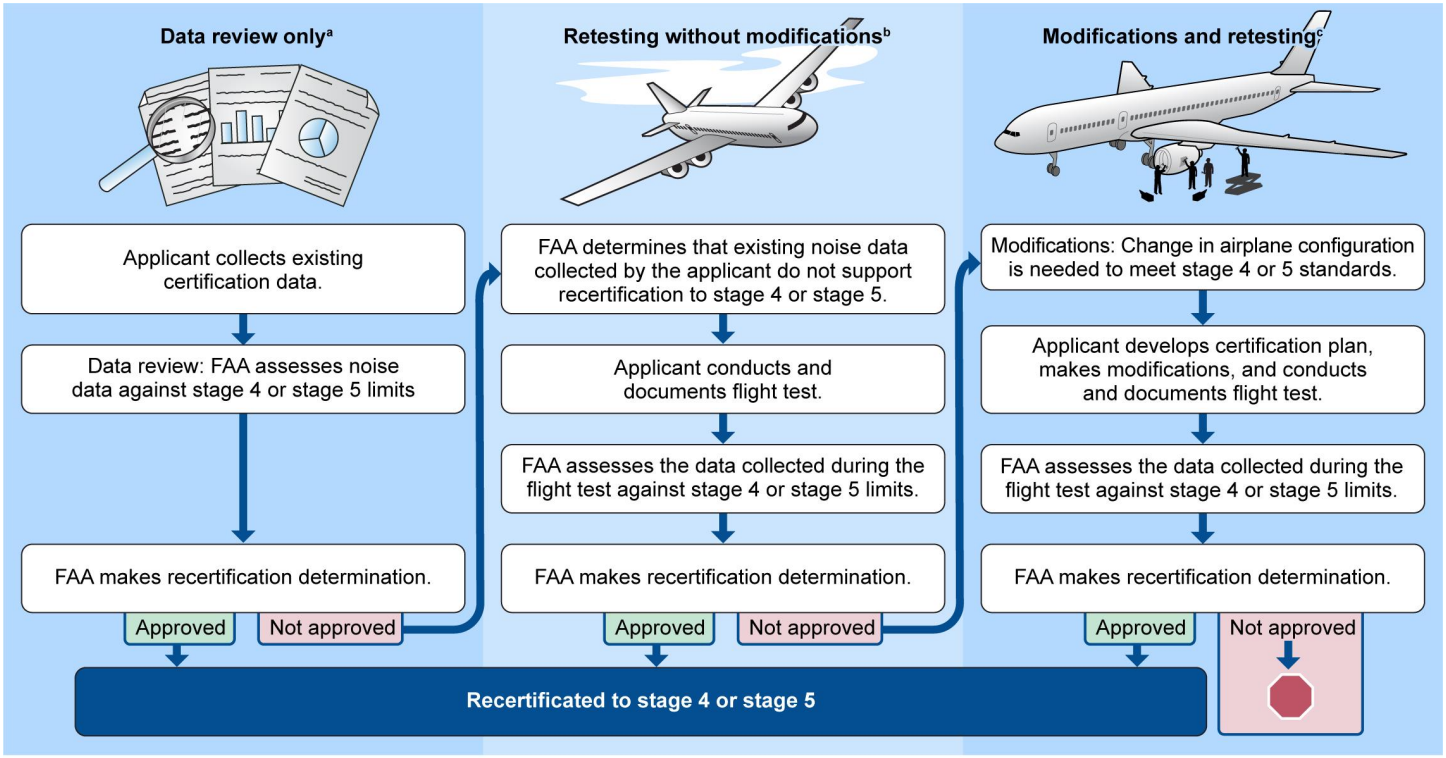
[b]FAA grants type, production, airworthiness, and other types of certificates for aircraft after all requirements have been met.

FAA's Role

FAA regulates airplane noise by ensuring that when an airplane is certificated for airworthiness, it also complies with U.S. noise standards. FAA implements these U.S. aviation noise standards according to federal statutes and its own regulations and provides guidance through advisory circulars and other documents. FAA is also responsible for recertificating airplanes to comply with a more stringent noise certification standard than the standard to which they were originally certificated. The recertification process occurs when requested by the manufacturer or operator and can range from reviewing airplane noise data to modifying and re-testing the airplane. In 2017, FAA issued an advisory circular with the intent to promote uniformity of implementation of the noise certification

requirements.[30] As part of the advisory circular, FAA provides guidelines for recertificating a stage 3 airplane to stage 4 or 5 noise standards. Figure 1 below provides an overview of FAA's process for recertification of a stage 3 airplane to a more stringent noise standard.

Figure 1: Overview of FAA's Process for Recertificating Airplanes to Stage 4 or Stage 5 Noise Standards



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-20-661

[a]If unable to recertificate using this process, the applicant has two additional recertification process options available, which are retesting without modifications or modifications and retesting.
[b]If unable to recertificate using this process, the applicant has one additional recertification process option available, modifications and retesting.
[c]If unable to recertificate using this process, the applicant has no additional recertification process options available.

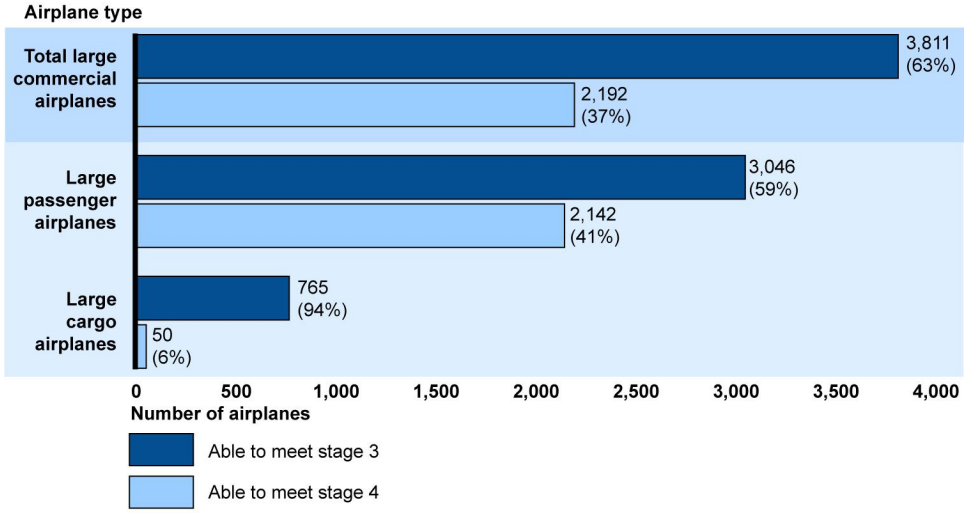
The Majority of U.S. Airplanes Are Stage 3, but Most Are Able to Meet More Stringent Noise

[30]FAA, Advisory Circular 36-4D, *Noise Standards: Aircraft Type and Airworthiness Certification* (Washington, D.C.: Oct. 12, 2017).

Standards, According to FAA and Aviation Stakeholder Data

The majority of commercial airplanes in the United States are certificated as meeting stage 3 noise standards, the oldest noise standards under which U.S. airplanes are allowed to operate. Specifically, according to FAA's analysis of the December 2017 U.S.-based in-service airplane fleet, airplanes certificated at stage 3 accounted for 3,809 of 6,003 (63 percent) of the large commercial airplane fleet.[31] Further, passenger airplanes comprise the overwhelming majority of the large commercial airplane fleet, and a majority of them are certificated as stage 3. Though cargo airplanes make up a small proportion of the commercial airplane fleet, almost all cargo airplanes are also certificated as stage 3 as of December 2017 (see fig. 2).

Figure 2: Number of Large Airplanes in the Commercial U.S. Fleet FAA Certificated as Meeting Stage 3 (Noisier) versus Stage 4 (Quieter) Noise Standards, December 2017



Source: GAO assessment of December 2017 Federal Aviation Administration (FAA) noise-based fleet composition analysis. I GAO-20-661

[31]The large commercial airplane fleet includes airplanes from network and low cost commercial passenger airlines, regional airlines, private operators, and airlines that offer charter and on-demand services.

Data table for Figure 2: Number of Large Airplanes in the Commercial U.S. Fleet FAA Certificated as Meeting Stage 3 (Noisier) versus Stage 4 (Quieter) Noise Standards, December 2017

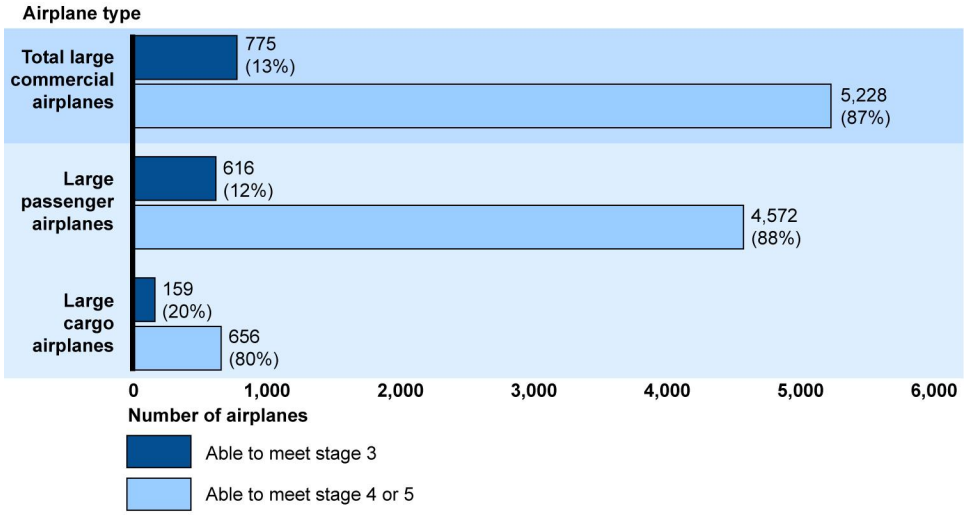
Airplane type	Number able to meet stage 3	Percentage able to meet stage 3	Number able to meet stage 4	Percentage able to meet stage 4
Total large commercial airplanes	3811	63	2192	37
Large passenger airplanes	3046	59	2142	41
Large cargo airplanes	765	94	50	6

Note: FAA's analysis of December 2017 U.S.-based in-service fleet data defines large airplanes as airplanes weighing 75,000 pounds or more. Accordingly, for the purpose of our review, we define large commercial airplanes as U.S.-based in-service commercial airplanes that weigh 75,000 pounds or more. Certificated noise level represents the designated noise level of an airplane at the time of certification. FAA's analysis was conducted based on fleet data prior to stage 5 certifications taking place. Additionally, stage 1 and 2 airplanes have been prohibited from operating in the 48 contiguous United States and the District of Columbia.

According to FAA officials we interviewed and data they provided, the certificated noise stage level of an airplane is not always representative of the actual stage level that the airplane could meet. For example, according to FAA's 2017 analysis, 3,128 of 3,811 (82 percent) of certificated stage 3 airplanes are able to meet stage 4 or stage 5 standards. Furthermore, according to this same analysis, the vast majority of all large commercial airplanes (87 percent) are able to meet stage 4 or stage 5 standards (see fig. 3).[32]

[32]For the purpose of this report, the term "able to meet" refers to airplanes that are capable of meeting other specified stage standards as currently configured.

Figure 3: Number of Airplanes in the Commercial U.S. Fleet FAA Estimated as Meeting Stage 3 Noise Standards Compared to Airplanes That Are Able to Meet More Stringent Stage 4 or Stage 5 Standards, December 2017



Source: GAO assessment of December 2017 Federal Aviation Administration (FAA) noise-based fleet composition analysis. | GAO-20-661

Data table for Figure 3: Number of Airplanes in the Commercial U.S. Fleet FAA Estimated as Meeting Stage 3 Noise Standards Compared to Airplanes That Are Able to Meet More Stringent Stage 4 or Stage 5 Standards, December 2017

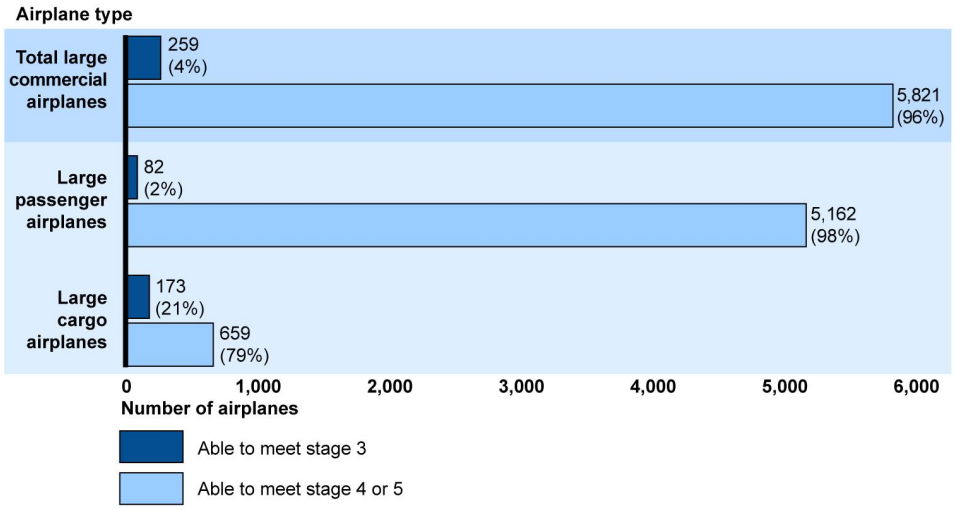
Airplane type	Number able to meet stage 3	Percentage able to meet stage 3	Number able to meet stage 4 and 5	Percentage able to meet stage 4 and 5
Total large commercial airplanes	775	13	5228	87
Large passenger airplanes	616	12	4572	88
Large cargo airplanes	159	20	656	80

Note: FAA's analysis of December 2017 U.S.-based in-service fleet data defines large airplanes as airplanes weighing 75,000 pounds or more. Accordingly, for the purpose of our review, we define large commercial airplanes as U.S.-based in-service commercial airplanes that weigh 75,000 pounds or more. Stage 1 and 2 airplanes have been prohibited from operating in the 48 contiguous United States and the District of Columbia.

Furthermore, according to FAA's 2017 analysis described above and based on updated fleet data provided by airlines we interviewed, nearly all commercial airlines' airplanes are able to meet stage 4 standards. For example, according to these data, approximately 98 percent of current large commercial passenger airplanes are able to meet stage 4 standards, while 79 percent of large commercial cargo airplanes are able to meet these same standards (see fig. 4). We expect these numbers

could further increase as airlines respond to the slowdown in passenger operations due to the COVID-19 pandemic by eliminating older, noisier airplanes from their fleets.

Figure 4: Estimated Number of Airplanes in the Commercial U.S. Fleet That Are Able to Meet Stage 4 or Stage 5 Noise Standards, January 2020



Source: GAO assessment of December 2017 Federal Aviation Administration (FAA) noise-based fleet composition analysis and January 2020 aviation stakeholder data. I GAO-20-661

Data table for Figure 4: Estimated Number of Airplanes in the Commercial U.S. Fleet That Are Able to Meet Stage 4 or Stage 5 Noise Standards, January 2020

Airplane type	Number able to meet stage 3	Percentage able to meet stage 3	Number able to meet stage 4 and 5	Percentage able to meet stage 4 and 5
Total large commercial airplanes	259	4	5821	96
Large passenger airplanes	82	2	5162	98
Large cargo airplanes	173	21	659	79

Note: FAA's analysis of December 2017 U.S.-based in-service fleet data defines large airplanes as airplanes weighing 75,000 pounds or more. Accordingly, for the purpose of our review, we define large commercial airplanes as U.S.-based in-service commercial airplanes that weigh 75,000 pounds or more. Passenger and cargo airlines we interviewed provided updated fleet composition information. As such, the total number of airplanes found in this figure differs from the totals previously in our report that were based on FAA's 2017 analysis. Additionally, stage 1 and 2 airplanes have been prohibited from operating in the 48 contiguous United States and the District of Columbia.

Based on FAA's 2017 analysis and interviews with aviation stakeholders, we found that because engine and airframe technology has outpaced the

implementation of noise standards, large commercial airplanes often are able to meet noise levels beyond their original certificated stage level.

1. **Original certification occurred prior to implementation of more stringent noise standards.** As previously noted, airplanes are certificated to the noise standards that are in effect at the time of certificate application. While airplane manufacturers must at a minimum build airplanes that meet noise standards, they can—and often do—build airplanes that will operate more quietly than called for by the standard. That is, before 2006, the highest certificated noise rating an airplane could obtain was stage 3, even when the airplane had noise level measurements that were lower than stage 3 requirements. FAA established stage 4 and 5 noise standards, which applied to large airplanes beginning in 2006 and 2017, respectively. Regardless of whether an airplane could meet today's stage 4 or 5 noise standards, any airplane certificated prior to 2006 could only be certificated to stage 3. According to our assessment of FAA's 2017 analysis, 3,185 of 6,005 (53 percent) of the large commercial airplane fleet was certificated prior to the establishment of stage 4 certification standards, and most of that fleet is able to meet stage 4 or 5 standards.
2. **More stringent noise requirements only apply to new aircraft type designs.** After 2006, when the stage 4 noise standards began to apply, airplane manufacturers could continue to manufacturer airplane designs that were previously certificated at stage 3. As a result, airplane manufacturers did not always recertificate airplanes they were manufacturing to the highest standard possible for that model, and some certificated stage 3 airplanes continue to be produced today. For example, according to one manufacturer we interviewed, it continues to manufacture certain airplane models using the original stage 3 certification, even though some of the models are able to meet more stringent standards, because stage 3 certification is sufficient for its customers and because recertification of these stage 3 airplanes could be costly.[33] However, according to all other airplane manufacturers we spoke with, they currently only manufacture airplanes certificated as stage 4 or stage 5. According to our assessment of FAA's 2017 analysis, nearly one-fifth of the large commercial fleet was manufactured with a stage 3 certification after

[33]Manufacturers are allowed to continue to produce aircraft models under the original certificate as long as the model has not been modified since certification.

stage 4 standards were established, even though almost all of these airplanes (96 percent) are able to meet stage 4 or stage 5 standards.

Aviation stakeholder groups we interviewed told us that continued advancements in airframe and engine technology have led to the production of newer and quieter airplane models. While FAA's 2017 analysis shows the proportion of commercial airplanes able to meet more stringent noise standards is high, the current proportion may be even higher as airlines—particularly passenger airlines—report that they have modernized their fleets in the interim. For example, representatives from all of the network and low cost commercial passenger airlines we interviewed told us that since FAA conducted its December 2017 noise-based fleet composition analysis, the airlines have modernized and updated their fleets to achieve more fuel efficiency.[34] For example, according to FAA's 2017 data, American Airlines' fleet included 46 McDonnell Douglas MD-80 (MD-80) airplanes.[35] American Airlines officials told us that the airline replaced the last of its MD-80s in September 2019. Similarly, FAA's 2017 analysis showed that 43 percent of Allegiant's fleet could not meet stage 4 standards. However, Allegiant representatives told us that in 2018, the airline replaced all 41 MD-80s with newer Airbus airplanes, and all airplanes in Allegiant's fleet now are able to meet stage 4 standards.

Furthermore, due to the decrease in travel demand amid the COVID-19 pandemic, some airlines have accelerated the retirement plan for parts of their fleet and have selected additional airplane models for retirement. For example, according to Delta, the airline is accelerating the retirement plan for its MD-88 fleet—which constitutes the majority of its remaining stage 3 fleet— and MD-90 fleet.[36] Furthermore, according to the airline, in response to an expected slow return to international travel operations, it has also decided to permanently retire its Boeing 777 in favor of using more fuel-efficient and cost-effective airplanes as demand for international travel returns. According to Delta officials we interviewed, the efficiency of the aircraft is the primary consideration in these

[34]These interviews occurred between October 2019 and January 2020, prior to COVID-19 being declared a public health emergency.

[35]The MD-80 was first certificated by FAA in 1980 and was produced until 1999.

[36]The MD-88 is a variant of the MD-80 series of single-aisle airliners developed by McDonnell Douglas.

retirements, but the retirements will also result in noisier airplanes being eliminated from their fleet.

Today, the U.S. commercial airplane fleet is younger and quieter when compared to the last time the federal government mandated a transition to quieter aircraft. For example, according to February 2020 Diio data we reviewed for passenger and cargo airlines, the average age of the passenger airplane fleet is approximately 12 years, and for the cargo fleet, about 21 years.[37] In comparison, in 2001, we reported that the average age of passenger and cargo airplane fleet was approximately 26 and 31 years old, respectively. Although passenger airlines appear to be modernizing their fleets at a faster pace than cargo airlines, representatives from all of the airlines stated they plan to continually modernize their fleets over time. See appendix I for an overview of the December 2017 major network airline fleet based on manufacturer information and noise levels.

Regional airlines, while a smaller presence, appear to be keeping pace with their network partners in composing fleets that primarily are able to meet stage 4 noise standards. Based on data provided by the manufacturers of U.S. regional airplanes, which includes both large and small regional airplanes, regional airplanes certificated at stage 3 accounted for 1,045 of 2,071 (50 percent) of the regional fleet. However, according to data provided by these manufacturers, 748 (72 percent) of the stage 3 regional airplanes are able to meet stage 4 or stage 5 standards. Accordingly, approximately 86 percent of the regional airplane fleet is able to meet more stringent stage 4 or stage 5 standards.[38]

Based on data we collected, the majority of the U.S. general aviation airplane fleet are able to meet stage 4 or 5 noise standards. Since FAA's 2017 data did not include comprehensive information for general aviation airplanes, we interviewed five manufacturers of general aviation airplanes—which together produce over 90 percent of the U.S. general aviation fleet—and gathered data on their fleets.[39] According to 2018 FAA

[37]We obtained these data from Diio, a private company that provides online access to U.S. airline financial, operational, and passenger data with a query-based user interface.

[38]As noted earlier, for the purpose of our review, we define large commercial airplanes as U.S.-based in-service commercial airplanes that weigh 75,000 pounds or more. We define small commercial airplanes as U.S.-based in-service commercial airplanes weighing less than 75,000 pounds.

[39]Our analysis includes all types of general aviation jet airplanes, regardless of weight.

data, the U.S. general aviation airplane fleet consisted of approximately 15,000 jet airplanes. Based on data provided by these manufacturers, 10,224 of 13,940 (73 percent) of their fleet are able to meet stage 4 or stage 5 standards. Of these general aviation airplanes, 8,899 (77 percent) have already been certificated or recertificated to the more stringent noise standards. Furthermore, the number of airplanes certificated at stage 3 will likely diminish in the future, as most manufacturers no longer produce stage 3 airplanes. For example, we spoke to the manufacturers for all large commercial and regional airplanes along with manufacturers that produce the large majority of general aviation airplanes. Only one of these manufacturers told us that it continues to produce stage 3 airplanes.

Stakeholders Generally Agreed That Phasing Out Stage 3 Airplanes Would Not Substantially Reduce Noise and Could Be Costly and Challenging

Because Most of the Fleet Is Able to Meet More Stringent Noise Standards, Benefits Such As Those Achieved In Past Phase-outs Would Be Limited

According to some stakeholders we interviewed, a phase-out of stage 3 airplanes would provide limited reductions in airport noise. As discussed previously, most airplanes for major airlines and the majority of general aviation airplanes are able to meet more stringent stage 4 standards, leaving only a small percentage of stage 3 aircraft in the fleet that do not already meet more stringent noise standards. For example, as reported above, we estimate that 259 (4 percent) of the airplanes in today's large commercial airplane fleet consist of stage 3 airplanes that cannot already meet stage 4 or stage 5 standards. However, we previously reported that when the stage 2 phase-out was mandated in 1990, the U.S. commercial airplane fleet included 2,372 stage 2 airplanes that did not meet stage 3

standards, which we estimate made up more than 56 percent of the U.S. jet fleet.[40]

According to some stakeholders, a phase-out of stage 3 airplanes would not substantially reduce airport noise because other factors—rather than noise from stage 3 airplanes—are key contributors to airport noise in recent years. One factor was a large increase in the number and frequency of flights at some commercial airports in recent years, prior to the COVID-19 pandemic.[41] For example, Seattle-Tacoma International Airport officials told us that their airport operations had increased substantially in recent years. According to FAA data, airline flights at Seattle-Tacoma International Airport increased by 48 percent from 2013 to 2019. Another factor is changes to flight procedures and routes. Stakeholders from various segments of the aviation industry—industry and trade organizations, airlines, an airport, a community group, and airframe and engine manufacturers—told us that key contributors to noise, such as changes in flight procedures and routes, are the focus of community noise concerns.[42]

While stakeholders indicated that a phase-out would not substantially reduce noise, they identified other limited benefits. For example, some stakeholders told us that phasing out the remaining stage 3 airplanes that cannot meet stage 4 standards could potentially generate environmental benefits, such as reduced greenhouse gas emissions because stage 4 and stage 5 airplanes have increased fuel efficiency and lower carbon footprints compared to stage 3 airplanes. In addition, airframe and engine manufacturers told us they might see increased revenue from more sales of stage 4 airplanes. However, for these manufacturers, the increased

[40]GAO-01-1053. This estimate is calculated based on the 2,372 stage 2 airplanes we previously reported on as not meeting stage 3 standards and comparing it to the overall fleet size of commercial jet airplanes in 1990, according to DOT's Bureau of Transportation Statistics.

[41]In response to the COVID-19 pandemic, airlines significantly reduced their services, and in some cases, completely suspended operations. For example, according to DOT's Bureau of Transportation Statistics, preliminary air traffic data for April 2020 estimates a 96 percent decrease in U.S. airline passengers, the lowest monthly level on record based on records since 1974.

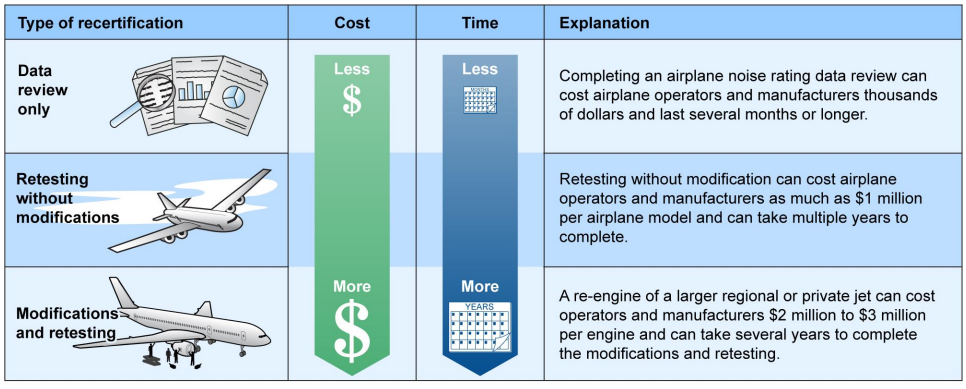
[42]We are currently conducting a review of community noise effects from flight path changes resulting from FAA's implementation of NextGen and related FAA community outreach. We intend to report on our findings in 2021.

sales would be offset by a loss of sales associated with their parts and servicing businesses that rely on stage 3 airplanes.

A Phase-out of Remaining Stage 3 Airplanes Could Be Costly for Some Operators

Generally, the cost of a phase-out would depend on several factors, including the parameters of the phase-out such as the length of time allowed and the methods by which operators replace their stage 3 aircraft. A phase-out would require recertificating airplanes to comply with a more stringent noise certification standard than the standard to which they were originally certificated. In some cases, this involves reviewing existing data; however, when the data are not available, it would involve retesting or modifying and retesting the aircraft.[43] According to FAA and interviews we conducted with aviation stakeholders—such as airlines, manufacturers, and industry associations—the cost and time required to recertificate an airplane vary widely depending on the type of review required, as shown in figure 5 and described below.

Figure 5: Examples of Costs and Timeframes to Recertificate Stage 3 Airplanes to Stage 4 Noise Standards



Source: GAO analysis of Federal Aviation Administration (FAA) and aviation stakeholder information. | GAO-20-661

Note: FAA would also incur costs and spend time under a phase-out such as by conducting data reviews and noise assessments as part of the recertification process.

- **Data review only:** Airlines and airframe manufacturers that already have the data to demonstrate that their stage 3 certificated airplanes are able to meet more stringent noise standards may require only a

[43]To obtain their initial noise certifications, airplanes are tested to determine noise levels. Therefore, any recertification to a more stringent noise level might require that the aircraft be retested.

data review, which is less costly than other types of recertification. This review involves obtaining and confirming that the original noise certification is correct and contains all needed information for recertification. The cost and time required to complete the data review can be dependent on how well the previous certification was documented. In such cases, some aviation stakeholders told us that no testing or modifications are needed for FAA to recertificate these airplanes to more stringent noise standards. As discussed previously, according to FAA's analysis, 63 percent of large commercial airplanes are certificated stage 3 airplanes. However, based on FAA's analysis, nearly 82 percent of these airplanes are able to meet stage 4 or stage 5 standards, meaning over half (52 percent) of the large commercial airplane fleet are certificated stage 3 but can meet more stringent noise standards and could potentially be recertificated using a data review only.

According to FAA, tracking down the needed data to demonstrate that an airplane meets more stringent noise standards can take the operators and manufacturers considerable time should the data not be readily accessible. Therefore, this process can cost operators and manufacturers thousands of dollars and last several months or longer. Furthermore, a major airline we interviewed estimated that a data review for recertification costs tens of thousands of dollars per airplane, and officials representing a commercial airplane manufacturer and a major commercial airline said the process may take up to one year to complete per noise data set (which may cover several models), depending on the age and condition of the original data collection.

- **Retesting without modifications:** If a certificated stage 3 airplane is able to meet stage 4 noise standards but the noise data for the airplane are incomplete or unavailable, FAA may require retesting to demonstrate that it meets the more stringent stage 4 standards. Retesting involves airlines or airframe manufacturers conducting a flight demonstration using equipment to measure noise at specific points identified by FAA. According to airlines and airframe manufacturers we interviewed, retesting an airplane costs considerably more than a data review. For example, representatives from one regional airplane manufacturer told us that retesting can cost hundreds of thousands of dollars per airplane model, and according to representatives from an airline we interviewed, retesting can cost as much as $1 million per airplane model, without modifications to the airplane. Two airframe manufacturers estimated that retesting without modifications can take between 2 and 3 years to complete. Furthermore, officials from one airline we interviewed told us that

costs would be significant if retesting is required as part of stage 3 phase-out. For example, officials estimated that it would cost the airline at least $5 million to retest the relevant fleet and said the process could take between 1 to 3 years to complete.

- **Modifications and retesting:** If an airplane is unable to meet stage 4 standards via a data review or retesting, operators and manufacturers would need to modify and retest it to determine if the modified airplane meets required noise standards. This is the most costly type of recertification because it involves making changes to the airplane in addition to the cost of retesting. According to four airplane manufacturers, some modifications have been developed to reduce airplane noise, some of which only marginally reduce noise, and the costs can vary widely, depending on the modification. Furthermore, these manufacturers also noted that modifying an airplane can negatively affect the airplane's performance, and many of the modifications are only available for larger airplanes.[44] In some cases, and more frequently with general aviation airplanes, the only way an airplane could meet stage 4 standards is by replacing its engine. According to selected manufacturers, a "re-engine" for larger regional and general aviation airplanes can cost $2 million to $3 million per engine and $1 million to $1.5 million for smaller general aviation airplanes. According to FAA and aviation stakeholders we interviewed, major modifications to and retesting of an airplane can take several years to complete. Unlike the options above, airplanes that go through this process would reduce the public exposure to noise.

In the event of a mandated stage 3 phase-out, not all airplanes could be recertificated to meet stage 4 or stage 5 noise standards. As such, by requiring operators to phase-out stage 3 airplanes, potentially before the end of the airplanes' lifecycle, operators could incur the costs for purchasing replacement airplanes sooner than they originally planned.[45] Some operators we interviewed indicated that they would consider

[44]For example, one stakeholder cited the following modifications that could make airplanes quieter but hinder efficiency: A "nacelle," which is a housing, separate from the fuselage that holds engines, fuel, or equipment on an aircraft. "Chevrons," which are the saw tooth pattern seen on the trailing edges of some jet engine nozzles. "Winglets," which are wingtip devices that are intended to improve the efficiency of fixed-wing aircraft by reducing drag.

[45]For example, the economic cost of phasing out stage 3 airplanes would include the interest cost associated with acquiring replacement airplanes sooner than originally planned.

whether to purchase or lease new airplanes in cases where modifications could not be made to the airplane to meet stage 4 standards, modifications are not available, or modifications are cost-prohibitive given the age or condition of the airplane. According to some aviation stakeholders we interviewed, in some cases, small charter businesses that might own only a few airplanes or regional airlines that are subject to contract scope clauses might be forced out of business due to financial constraints or because of the lack of available comparable airplanes to meet their needs.[46] For example, representatives of one regional airline we interviewed told us that a phase-out of stage 3 airplanes could force them to retire a significant portion of their fleet without having a path forward for replacing the airplanes.

Phasing-out the Remaining Stage 3 Airplanes Could Also Present Other Challenges

Stakeholders identified other challenges that could make the phase-out of stage 3 airplanes a hardship for some sectors of the industry:

- **There are no current technological solutions to upgrade stage 3 airplanes, and demand for developing them could be limited**. According to stakeholders we interviewed, currently, there are no large-scale technological solutions to modify stage 3 airplanes to meet stage 4 or stage 5 noise standards. In the case of a mandated phase-out of stage 3 airplanes, technological solutions could potentially be developed for these airplanes, but since the vast majority of current stage 3 airplanes are able to meet stage 4 or stage 5 standards, the demand for such technological solutions could be limited. Furthermore, representatives of some stakeholders told us they were unaware of any ongoing or future plans to develop modifications to allow stage 3 airplanes to meet stage 4 noise standards. In contrast, as we reported in 2001, over half of stage 2 airplanes were modified during the previous phase-out using available technologies.[47]
- **Operators would be disproportionately affected.** Operators in certain sectors could be affected the most by a stage 3 phase-out. In particular, as we reported earlier, the cargo sector tends to fly older

[46]A scope clause is part of a contract between a major airline and the trade union of its pilots that limits the number and size of aircraft that may be flown by the airline's regional airline affiliate.

[47]Modifications made during the previous phase-out primarily consisted of using "hush kits" to modify an airplane's engines to meet stage 3 noise standards. GAO-01-1053.

airplanes. For example, based on FAA's analysis and updated information we received from aviation stakeholders we interviewed, 21 percent of large cargo airplanes are stage 3 airplanes that are unable to meet stage 4 standards compared to 2 percent in the passenger sector. Further, general aviation airplane manufacturers we interviewed reported that 27 percent of their fleet cannot meet stage 4 or stage 5 standards. Two general aviation stakeholder groups we interviewed told us that a phase-out could be cost prohibitive for most owners of stage 3 general aviation airplanes.

- **International issues would need to be addressed.** Since foreign registered aircraft access U.S. airspace not only for passenger and cargo operations but also for private operations and, according to one stakeholder we interviewed, to seek maintenance services, a stage 3 phase-out would have effects beyond the U.S. For example, ICAO urges countries not to introduce a phase-out of stage 3 airplanes before considering other alternatives.[48] Further, according to some stakeholders we interviewed, phased-out stage 3 airplanes might be sold to less restrictive regions of the world, resulting in only a transfer of airplane noise to other parts of the world.[49] However, according to one stakeholder, these airplanes would likely be used to replace even noisier airplanes, resulting in an improvement to overall airplane noise levels for the impacted regions.

Stakeholders Identified Key Considerations for Addressing Airplane Noise

Airport noise abatement is a complex issue and is not solely dependent on aircraft certification levels. According to FAA, there are marginal benefits to a stage 3 phase-out because many aircraft in the fleet could meet higher certification levels today.[50] Therefore, according to representatives of some stakeholders we interviewed, a solution based

[48]We discuss ICAO's position in more detail later in the report.

[49]To the extent that operators are able to sell phased-out stage 3 airplanes in markets outside of the United States, the cost of a phase-out would be lower, all else the same.

[50]FAA also noted that prior technological advances resulted in actual airplane noise benefits. For example, as we previously reported, the number of people in the United States exposed to significant airport noise declined from roughly 7 million people in 1975 to about 309,000 in 2012. This change reflects large decreases in the size of areas that are exposed to significant airport noise and is primarily due to improvements in aircraft technology. GAO-12-890.

solely on an airplane's noise certification level is not likely to reduce the actual or perceived impact of noise. Additionally, according to stakeholders, competing local interests—the surrounding community's desire for quieter airspace and increased demand for travel and air cargo also contribute to the difficulty in addressing noise issues.

Although the fleet composition of stage 3 airplanes today is very different than the fleet composition of stage 2 airplanes at the time of the previous phase-out, based on experiences with similar transitions, stakeholders identified the following considerations that would be beneficial to any phase-out of noisier airplanes:

- **Stakeholder Involvement.** Several stakeholders told us that industry involvement is critical to any future phase-out of stage 3 airplanes. Thirty-two of 33 stakeholders identified the need for FAA to have consistent and clear messaging when collaborating with them. For example, one stakeholder group said that during the stage 2 phase-out, FAA set the bar too high regarding the amount of noise reduction that could be expected, and this caused some problems with communities.
- **Timing.** According to six stakeholders, it is critical to build in enough lead time for a transition and to define a timeline that is agreeable to the government and aviation stakeholders. For example, as part of the November 1990 requirement to phase-out stage 2 airplanes, the phase-out of large airplanes was accomplished with a more than 9-year timeframe through 1999.[51] If a phase-out of stage 3 airplanes is to take place, some stakeholders said it should occur over a similarly long period of time.

In addition, some stakeholders stated that it was a good idea to have different timeframes for the prohibition of large and small stage 2 airplanes. The ban of smaller stage 2 airplanes went into effect in September 2013 with prohibition after December 2015 while, as previously noted, the phase-out of large airplanes was accomplished from 1990 through 1999. Some stakeholders indicated that some operators will require more time than others to determine how to address the prohibition and that staggered timing is crucial to minimize economic impact. For example, representatives from one manufacturing groups said that operators of general aviation airplanes, such as small businesses, may

[51]For this review, we are defining large airplanes as airplanes weighing more than 75,000 pounds.

not be able to afford to modify their airplanes or to purchase or lease a newer one that meets more stringent noise standards in a short amount of time.

ICAO Suggests a Cautious, Targeted Approach to Noise Reduction

In 2011, ICAO adopted the policy of Balanced Approach to Aircraft Noise Management (Balanced Approach). ICAO's Balanced Approach consists of identifying the noise problem at a specific airport and analyzing various measures that can be classified into four principal elements: (1) reduction of noise at source, (2) land-use planning and management, (3) noise abatement operational procedures, and (4) operating restrictions. The goal is to address noise problems on an individual airport basis and to identify the noise-related measures that achieve maximum environmental benefit most cost-effectively using objective and measurable criteria.

Further, in an October 2019 resolution, ICAO's Assembly concluded that a general phase-out of stage 3 aircraft operations by all the countries which imposed a phase-out on operations of stage 2 aircraft is not supported on cost-benefit grounds.[52] ICAO urges countries not to introduce a phase-out before fully assessing available measures to address the noise problem in accordance with its Balanced Approach. For countries that decide to proceed with a phase-out of stage 3 aircraft, ICAO suggested a number of measures. For example, ICAO suggests that stage 3 aircraft of individual operators be eliminated gradually over a period of not less than 7 years. Additionally, if stage 3 restrictions are introduced at certain airports, such restrictions should be based on the balanced approach and relevant ICAO guidance and should be tailored to the specific requirements of the airport concerned.[53]

[52]In the United States, noise standards are referred to as "stages," whereas ICAO, the international body that sets international noise standards for aircraft, refers to them by the chapter of the ICAO document in which the standard appears. Unless otherwise noted, we refer to the standards in terms of stages.

[53]FAA points out, however, that tailored local solutions can create their own challenges for airlines and other aircraft operators, which may then have to navigate a "patchwork quilt" of different noise regulations in different locations even within a single nation, state, or region.

Agency Comments

We provided a draft of this report to DOT for review and comment. DOT provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, the Administrator of FAA, and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or krauseh@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

Heather Krause
Director, Physical Infrastructure Issues

Appendix I - Number of U.S.-Based Airplanes That Are Able to Meet Stage 4 or Stage 5 Noise Standards

In December 2017, the U.S.-based network and low cost airlines' fleets consisted of various types of Boeing and Airbus airplanes. Table 3 shows how many of the Boeing and Airbus airplanes, by series type, meet stage 4 or stage 5 noise standards, as of December 2017. As the table indicates, the vast majority of the airplanes of each manufacturer are able to meet stage 4 or stage 5 standards.

Table 2: Percentage of U.S.-Based In-service Network and Low Cost Commercial Airplanes That Are Able to Meet Stage 4 or Stage 5 Noise Standards, by Manufacturer and Series, December 2017

			Airplanes that meet stage 4 or stage 5 standards	
Manufacturer	**Airplane series type**	**Total airplanes**	**Number**	**Percentage**
Boeing	737	1,779	1,453	82%
	757	445	445	100%
	767	351	341	97%
	777	213	213	100%
	MD-80	213	0	0%
	717	110	110	100%
	MD-11	110	110	100%
	747	88	72	82%
	787	67	67	100%
	MD-90	64	64	100%
	DC-10	39	0	0%
	DC-9	17	0	0%
	727	10	0	0%
Total Boeing	**--**	**3,506**	**2,875**	**82%**
Airbus	A320	1,210	1,118	92%
	A300	120	75	63%
	A330	90	90	100%
	A310	7	0	0%
	A350	6	6	100%
Total Airbus	**--**	**1,433**	**1,289**	**90%**
Overall total	**--**	**4,939**	**4,164**	**84%**

Source: GAO analysis of Federal Aviation Administration (FAA) data. | GAO-20-661

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, Jonathan Carver (Assistant Director); Ray Griffith (Analyst-in-Charge); Spencer Barnes; Jenny Chanley; Tim Guinane, David Hooper; Josh Ormond; Amy Rosewarne; and Pamela Vines made key contributions to this report.

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