U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

November 15, 2017

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

Commercial Aviation: Pilots' and Flight Attendants' Exposure to Noise aboard Aircraft

Dear Mr. DeFazio:

Airline pilots and flight attendants, working in the cockpit and cabin, are exposed to noise as a routine part of their jobs. This noise may come from aircraft engines during takeoff and landing or from high-speed air flow over the fuselage during flight. Exposure to elevated noise levels can cause permanent changes in hearing, diminished ability to communicate, and non-auditory effects such as fatigue. The Occupational Safety and Health Administration (OSHA), which sets and enforces standards related to working conditions,[1] established a noise exposure standard that requires employers to take certain actions when an employee's noise exposure reaches a level deemed to be unsafe.[2] The Federal Aviation Administration (FAA) assumed responsibility for the safety and health aspects of cockpit and cabin crewmember working environments in 1975,[3] but in 2013, FAA announced in a policy statement that OSHA would have authority to enforce its occupational noise exposure standard in the cabins of aircraft in operation, where flight attendants work.

You asked us to provide information on noise levels experienced by crewmembers on commercial service aircraft and their access to hearing protection. We examined: (1) what is known about aircraft cabin and cockpit noise levels compared with occupational noise exposure standards and (2) selected airlines' policies on hearing protection for crewmembers.

To address these objectives we reviewed FAA's regulations and guidance pertaining to interior aircraft noise, the occupational noise exposure standard from OSHA, and the recommended occupational noise exposure limit from the National Institute for Occupational Safety and Health (NIOSH). We assessed OSHA's data on enforcement activity related to aircraft noise from August 2013, when OSHA assumed its authority to enforce its noise standard in the cabin, to May 2017. We also reviewed FAA's analysis of four safety and oversight databases to identify reports on aircraft noise made in the previous 5 years and data from the Aviation Safety

[1] OSHA is charged with enforcing the Occupational Safety and Health Act of 1970 (OSH Act), Pub. L. No. 91-596, 84 Stat. 1590.

[2] 29 C.F.R. § 1910.95.

[3] Under 29 U.S.C. § 653(b)(1) of the OSH Act, OSHA is precluded from applying its occupational safety and health standards to the working conditions over which a federal agency has exercised its statutory authority. FAA exercises its statutory authority pursuant to 49 U.S.C. § 44701.

Reporting System (ASRS), which is a database maintained by the National Aeronautics and Space Administration (NASA), to identify reports submitted from January 2012 through March 2017 about noise interference with onboard crewmembers' communication.[4] We excluded data on noise concerns from malfunctioning equipment because while it may contribute to a crewmember's noise exposure, it does not represent normal operating conditions of an aircraft. To determine the reliability of the data we used, we assessed agency documentation and interviewed officials and concluded that the data were sufficiently reliable for our purposes. We searched academic, government, and trade publications for studies that measured noise levels inside aircraft, identifying 10 studies that met our criteria for methodological quality. Six of these measured noise in aircraft cabins, 2 measured cockpit noise, and 2 of the 10 measured noise in both locations. In addition, we interviewed officials from FAA, OSHA, NIOSH, seven labor groups representing pilots and flight attendants, two aviation trade associations, the four largest aircraft manufacturers, and eight mainline and regional airlines.[5] We selected the airlines to include those that had a range of aircraft types and that had the most passenger enplanements in the U.S. in 2016, the most recent data available. Our interviews with these airlines provided information on their aircraft noise tests and on hearing protection policies, and are not generalizable to all airlines. Also, we could not confirm all of the information provided in interviews with airlines and manufacturers, because the companies did not make the supporting documentation available to us, citing its proprietary nature. See enclosure I for a full description of our scope and methodology.

We conducted this performance audit from March 2017 to November 2017 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.

Results in Brief

While information on aircraft noise is limited, the studies and data we reviewed suggest that aircraft cabin and cockpit noise levels likely do not exceed the OSHA standard. Of the 10 studies that we reviewed, none found noise levels that clearly exceeded this standard. FAA and OSHA have received few complaints from crewmembers related to aircraft noise levels. For example, crewmembers submitted two complaints about ambient aircraft noise levels to OSHA since the FAA policy statement was issued in 2013, and no reports related to aircraft noise were submitted to FAA's safety and oversight-related databases in the last 5 years. Airlines and aircraft manufacturers that we interviewed told us that noise measurements taken in their aircraft are below the OSHA standard. However, officials from labor groups representing pilots and flight attendants told us that while noise levels likely do not exceed the OSHA standard, they believe crewmembers nonetheless are sometimes exposed to unsafe levels of noise that could result in hearing loss or fatigue. Officials from all eight of the airlines we spoke with said that they allow pilots to wear hearing protection equipment, such as noise-reducing headsets, and officials from five of these airlines said they allow flight attendants to wear ear plugs, in

[4] The ASRS receives, processes, and analyzes voluntarily submitted, anonymous aviation safety incident reports from pilots, flight attendants, and others. The database is administered by NASA for FAA and is a public-safety data repository.

[5] Mainline airlines provide domestic and international passenger and cargo service on larger aircraft. Regional airlines provide domestic and limited international passenger service, generally using aircraft with fewer than 90 seats, and cargo service to smaller airports. See enclosure I for full list of study participants.

aircraft in operation. According to officials from three of the crewmember labor groups we interviewed, use of this equipment appears to be limited. Officials from the pilot labor groups we spoke with said noise-reducing headsets can be expensive or uncomfortable, and some models are not compatible with some aircraft communications systems.

We are not making any recommendations in this report.

Background

According to NIOSH, a federal research agency charged with the examination of occupational health hazards,[6] each year, approximately 22 million workers are exposed to noise levels that may be hazardous to their hearing and may cause physiological stress, cardiovascular disease, hypertension, and disruption of job performance. Noise is measured in units of sound pressure called decibels with a sound level meter or a noise dosimeter.[7]

Occupational Noise Exposure Standards

OSHA has established an occupational noise exposure standard that requires employers to administer a hearing conservation program when noise exposures reach 85 decibels over an 8-hour period, which OSHA refers to as an action level.[8] The program should include training, annual hearing tests, hearing protection equipment for employees, and other actions. OSHA also established the permissible exposure limit, which is a legal limit for employees' exposure to noise and is set at 90 decibels over an 8-hour period.[9] OSHA determines acceptable exposure limits using a 5-decibel exchange rate, so that for every 5-decibel increase or decrease of noise, the allowable exposure times are reduced by half or doubled, respectively.

NIOSH, though not responsible for enforcing workplace safety, has established a voluntary recommended exposure limit for occupational noise exposure that is different from the OSHA action level.[10] Like OSHA's action level, NIOSH's limit recommends that an employee's exposure be limited to an 8-hour time-weighted average of 85 decibels. Where NIOSH's recommended limit differs from the OSHA standard is in its use of a 3-decibel exchange rate,

[6] The OSH Act established NIOSH, which is part of the U.S. Department of Health and Human Services' Centers for Disease Control and Prevention. Pub. L. No. 91-596, § 22, 84 Stat. 1590,1612. NIOSH is responsible for recommending occupational safety and health standards and for describing safe exposure concentrations.

[7] OSHA and NIOSH noise measurements are expressed in A-weighted decibels, an adjustment intended to match the perception of loudness by the human ear. According to OSHA, examples of some common sources and their expected noise levels are that a freight train passing at 100 feet away would be expected to result in a noise level of around 80 decibels and a construction site would be expected to result in a noise level of around 100 decibels. A dosimeter is a wearable sound level meter that measures and stores the sound levels experienced by the test subject during an exposure period and calculates a time-weighted average noise value.

[8] A time-weighted average is used to calculate an employee's exposure to noise over an 8-hour day, which accounts for the average of different exposure levels during an exposure period. 29 C.F.R. § 1910.95.

[9] When noise exposure exceeds the permissible exposure limit, employers must use administrative or engineering controls to reduce noise levels, and provide hearing protection equipment if those controls fail. 29 C.F.R. § 1910.95(b).

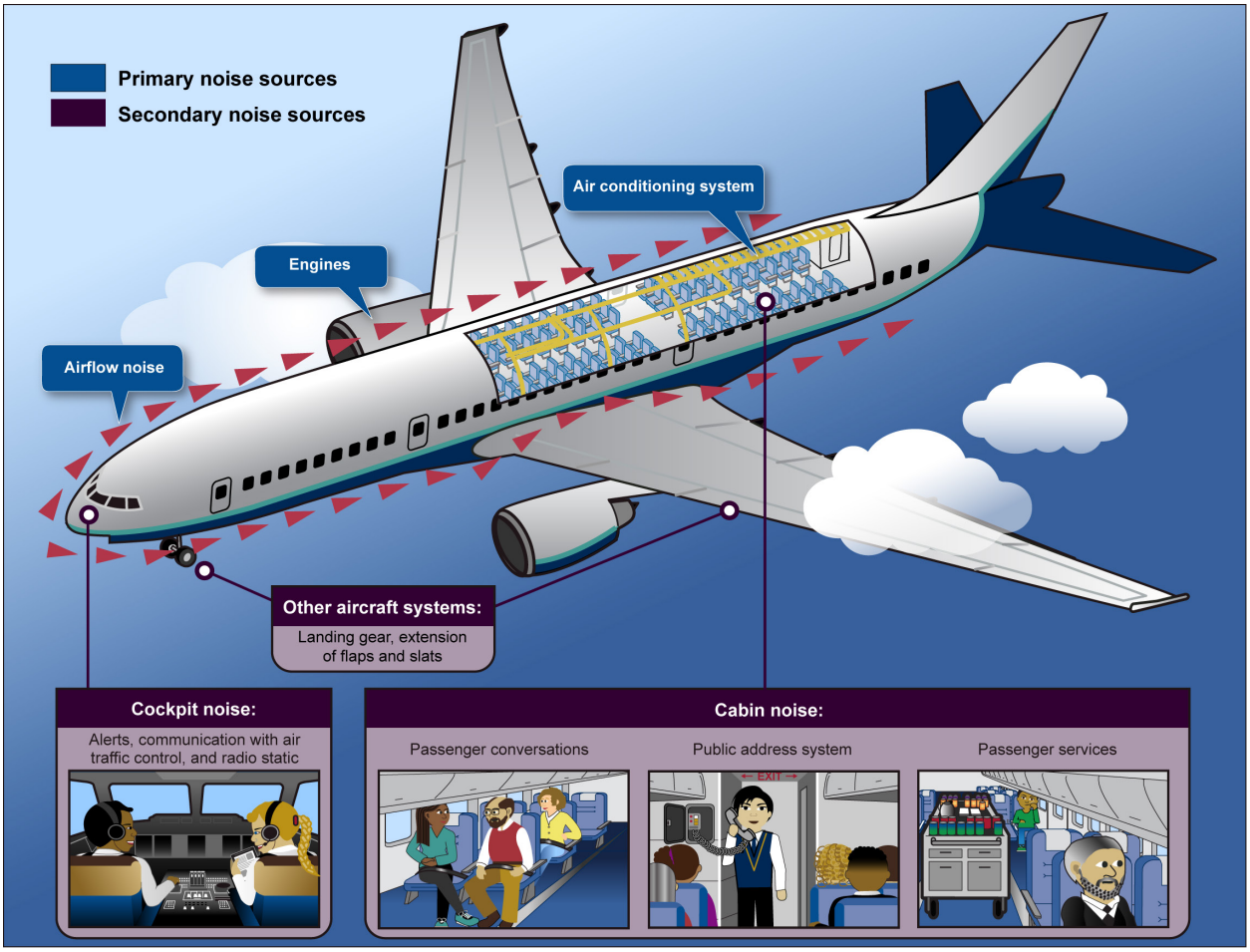
[10] Department of Health and Human Services, National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Noise Exposure* (Cincinnati, Ohio: June 1998).

rather than the 5-decibel exchange rate OSHA uses.[11] NIOSH's lower exchange rate results in shorter allowable exposures for noise levels above 85 decibels than OSHA's action level. For example, under the OSHA action level, an employee can be exposed to noise levels of 100 decibels for one hour, compared to 15 minutes under the NIOSH recommended exposure limit.

Sources of Interior Aircraft Noise

Aircraft generate many noises, both intermittent and continuous and located both inside and outside the aircraft, with the greatest amounts of noise being generated by the air flow around the aircraft, the engines, and the air conditioning systems, as illustrated in figure 1.

Figure 1: Examples of Sources of Interior Aircraft Noise



Source: GAO. | GAO-18-109R

The sources and level of noise vary depending on aircraft age, engine type and location, phase of flight, aircraft speed, and the listener's location. For example, pilots working in the cockpit hear the aircraft's radio and alert systems, while flight attendants working in the cabin hear the public address system and passenger conversations. Advances in engineering have decreased

[11] OSHA uses a 5-decibel exchange rate because it determined this accounts for the time during the workday that a worker was not exposed to noise hazards. NIOSH has stated that the 3-decibel exchange rate is the method most firmly supported by scientific evidence for assessing hearing impairment as a function of noise level and duration.

cabin noise levels substantially over the years through innovations in aircraft designs and new technologies. Examples include making the shape of the aircraft more aerodynamic; engine modifications, such as lowering fan speeds; and technologies to reduce the amount of noise and vibration experienced in the aircraft, such as new insulating materials and advances in noise and vibration suppression systems that are installed in some aircraft.

FAA's and OSHA's Roles and Responsibilities

As noted earlier, although OSHA is responsible for working conditions for most private-sector and some public-sector employees, in 1975, FAA asserted responsibility for the regulation of occupational safety and health standards for aviation crewmembers.[12] As part of FAA's airworthiness standards, FAA requires that cockpit noise and vibration levels not interfere with the safe operation of the aircraft and that public address system announcements are audible by the cabin's occupants.[13] However, neither regulation dictates a specific noise exposure limit. FAA has issued guidance for airlines and manufacturers on recommended noise levels for cockpit and certain crew rest areas in order to reduce the effect of noise on crewmembers' sleep.[14] In 2013, in response to a federal requirement,[15] FAA issued a policy statement making OSHA's noise exposure standard, among other OSHA standards, applicable to the working conditions of cabin crewmembers—but not pilots—on aircraft in operation.[16] FAA and OSHA agreed that OSHA would respond to complaints through written and oral communication and would coordinate with FAA if workplace inspections were necessary.[17]

Information on Aircraft Noise Is Limited but Suggests Levels Do Not Exceed OSHA's Standard

Cabin Noise Levels

None of the eight published studies we reviewed that conducted measurements inside aircraft cabins definitively showed noise levels in excess of OSHA's action level.[18] Direct comparisons

[12] 29 U.S.C. § 653(b)(1).

[13] 14 C.F.R. § 25.771(e), 14 C.F.R. § 25.1423(c).

[14] FAA recommends that in cockpits with noise levels above 88 decibels efforts should be made to aid pilot communication, such as installing door seals, acoustical insulation, and the use of noise-cancelling headsets or other hearing protectors. See Department of Transportation, Federal Aviation Administration, *Advisory Circular: Cockpit Noise and Speech Interference Between Crewmembers*, AC 20-133 (Mar. 22, 1989). FAA also recommends that long-haul crew rest areas should be designed with the objective to have noise levels during cruise flight in the range of 70 to 75 decibels. See Department of Transportation, Federal Aviation Administration, *Advisory Circular: Flightcrew Member Rest Facilities*, FAA AC 117-1 (Aug. 21, 2013).

[15] FAA Modernization and Reform Act of 2012. Pub. L. No. 112-95. § 829.126 Stat. 11,134.

[16] Department of Transportation, Federal Aviation Administration, *Occupational Safety and Health Standards for Aircraft Cabin Crewmembers* (Washington, D.C.: Aug. 21, 2013). The policy statement also included OSHA's standards for hazard communication (19 C.F.R. § 1910.1200) and bloodborne pathogens (19 C.F.R. § 1910.1030). FAA determined that an aircraft is in operation from the time it is first boarded by a crewmember, before a flight, to the time the last crewmember leaves the aircraft after completion of that flight.

[17] Department of Transportation, Federal Aviation Administration and Department of Labor, Occupational Safety and Health Administration, *Occupational Safety and Health Standards for Aircraft Cabin Crewmembers: Memorandum of Understanding between OSHA and FAA,* (Washington, D.C.: Aug. 26, 2014).

[18] Enclosure II provides details on each of the studies we reviewed.

between most of the studies and OSHA's action level were difficult, because the studies generally did not publish results in the 8-hour time-weighted average format with a 5-decibel exchange rate that OSHA uses. The single study that used this format reported noise levels below the OSHA action level on a four-engine regional jet, the Avro RJ85, when using dosimeters to measure entire flight attendant work periods.[19] The seven additional studies we reviewed reported cabin noise levels in other formats, such as simple averages of all the measurements taken, but generally showed average noise levels to be below 85 decibels on a variety of jet and turboprop-powered mainline and regional aircraft such as the Boeing 737 and 777, the Airbus A321 and A330, and the Bombardier CRJ-700 and DHC-8 Q400.

We also compared the studies' findings to NIOSH's recommended limit, which is not a legal requirement, but rather a recommendation. Two of the eight studies we reviewed indicated that noise in certain types of aircraft may reach or exceed NIOSH's recommended limit in the case of crewmembers who work for durations longer than 8 hours. These studies reported cabin noise levels in the format used by NIOSH's recommended exposure level (8-hour time-weighted average with a 3-decibel exchange rate). The aforementioned study using dosimeters on the Avro RJ-85 concluded that 3 of 20 flight attendant shifts had noise levels in excess of the NIOSH limit, and the other reported sound levels from one flight attendant shift on a long duration flight that were near NIOSH's recommended limit.

Officials from the eight airlines and four aircraft manufacturers we interviewed told us that they conduct tests of noise onboard aircraft and have found that noise levels are consistently below both the 85-decibel level specified in both the OSHA standard and NIOSH's recommended limit. Each of the aircraft manufacturers told us that they have designed cabins to meet certain noise levels in response to customer demand and that they conduct tests to confirm these levels for each new aircraft model. Officials from seven of the selected airlines told us that they have conducted cabin noise level testing on their aircraft in service, generally by placing wearable dosimeters onto flight attendants for entire work periods, and five of these airlines told us that this testing was in response to the 2013 FAA policy statement. These officials told us that the sound levels they measured varied by aircraft type and position in the cabin, but the recorded noise levels were all below 85 decibels on an 8-hour time-weighted average basis.[20]

Cockpit Noise Levels

Less comprehensive information is available about cockpit noise levels. We identified only four studies that measured cockpit noise levels, and while none of them reported results in the 8-hour time-weighted average format, each of them reported average noise levels below 85 decibels. These studies used a variety of measurement techniques such as a mannequin equipped with microphones to measure noise, a hand-held sound level meter, or pilots outfitted with dosimeters during flight. The studies conducted measurements on several different mainline and regional aircraft such as the Boeing 747 and 757, the Bombardier DHC-8 Q400, and the Airbus A340 and A319.

[19] Dosimeter measurements of entire flight attendant work periods could also include significant time spent not onboard an aircraft, such as time spent waiting for a flight in the terminal. Additionally, as of the end of 2016, the 10 largest U.S. airlines did not operate any Avro RJ-85 series aircraft.

[20] Airline officials told us that they measured entire flight attendant work periods, which include time spent in airport terminals, because this more accurately reflected their true exposure to noise, and that it was not possible to isolate just the time spent in an aircraft cabin from these measurements.

The four aircraft manufacturers told us that they test cockpit noise levels in each new aircraft model and have found that levels are below 85 decibels. The airlines we spoke with told us that they have not tested cockpit noise levels on aircraft in service, and that they do not regard cockpit noise levels as posing a problem for pilot communications or other safety concerns.

Pilot and Flight Attendant Concerns Related to Aircraft Noise

Labor groups representing pilots and flight attendants told us that they have concerns about the amount of noise exposure their members receive onboard aircraft; however, there have been few noise-related complaints made by pilots and flight attendants to OSHA, FAA, and the Aviation Safety Reporting System (ASRS). Labor groups representing flight attendants told us that they experience especially high levels of noise exposure when working in turboprop-powered aircraft, older aircraft, and aircraft with tail-mounted engines, such as the McDonnell Douglas MD-80 series.[21] Officials from labor groups representing pilots told us that pilots experience high levels of noise in certain aircraft due to equipment cooling fans, the configuration of the air conditioning system, and equipment such as windshield wipers. While we do not consider noises from equipment malfunctions as part of the daily operations of an aircraft, labor officials representing both groups of crewmembers told us that these malfunctions, such as faulty door seals, can create particularly loud noises. According to airline officials we interviewed, faulty door seals are not common, and when they occur, they are typically repaired before the next flight.

Labor groups representing flight attendants said that while cabin noise levels are likely below the OSHA action level, the noise exposure crewmembers do experience can result in difficulty communicating, fatigue, and, with long-term exposure, hearing loss. Labor officials expressed concern that OSHA's 90-decibel permissible exposure limit, which is the sound level at which employers take steps to reduce noise and is higher than OSHA's action level standard, may not be sufficient to protect crewmember health and safety. These officials cited research conducted by NIOSH that estimated around 25 percent of the population would experience noise-induced hearing loss over a 40-year career when exposed to that level of sound daily.[22]

Nonetheless, OSHA has received only two complaints of high ambient cabin noise levels since the 2013 FAA policy statement was issued, while during the same time period it received more than 600 complaints in the commercial passenger aviation sector in general.[23] In these two instances, OSHA conducted an informal review, in response to which the airlines provided noise-testing data from aircraft manufacturers, documenting noise levels in an array of aircraft flown by the airlines. The data showed that for the 16 aircraft included in the documentation, cruise flight noise levels were below the OSHA action level. Following its review, OSHA determined that no violation had occurred. FAA officials also told us that they have not received any complaints during their routine meetings with labor groups representing pilots and flight

[21] As of the end of 2016, the 10 largest U.S. airlines operated 238 MD-80 series aircraft.

[22] NIOSH defines noise-induced hearing loss as a material hearing impairment with reductions in the hearing threshold at certain sound frequencies of more than 25 decibels.

[23] During this time, OSHA received one other complaint related to malfunctioning equipment on one specific flight.

attendants, and that they searched several of their safety and oversight reporting system databases for noise-related complaints and found none submitted in the last five years.[24]

We also searched NASA's ASRS database for reports submitted by aviation workers since January 2012 that discussed aircraft noise levels interfering with crewmembers' ability to effectively communicate. We limited our search to these reports because FAA requires that aircraft noise in the cockpit does not interfere with the safe operation of the aircraft and that public address system announcements are audible by the cabin's occupants. We found that out of the more than 26,000 reports submitted during the period, only 10 referred to communications difficulties caused by normal ambient noise levels.[25] These reports included complaints about difficulty hearing other crewmembers or radio transmissions, as well as complaints about being distracted or fatigued by loud noises.

Hearing Protection Policies of Selected Airlines Vary

In general, FAA does not prescribe airline policies on crewmembers' hearing protection, other than if the crewmember does wear hearing protection, it must not interfere with safety-related duties.[26] In accordance with FAA's 2013 policy statement, airlines are only required to provide hearing protection for cabin crewmembers—but not pilots—as part of a hearing conservation program if noise levels are in excess of the OSHA action level.[27] FAA requires pilots to use headsets when the aircraft is below 18,000 feet, but, depending on the model, these headsets may or may not protect hearing.[28]

We asked eight airlines about their policies regarding hearing protection for flight attendants and pilots. A summary of their responses is provided in table 1.

[24] FAA searched the Program Tracking and Reporting Subsystem (PTRS), the Safety Assurance System (SAS), the Air Transportation Oversight System (ATOS), and the Accident Incident Database System (A/IDS) using several noise-related terms, such as noise, decibel, noise, noise level, loud noise, and loud sound, among others.

[25] We found an additional 30 reports that discussed communications difficulties caused by noise from malfunctioning aircraft equipment, such as a radio with excessive static or a leaking door seal.

[26] 14 C.F.R. § 121.135, 14 C.F.R. § 121.397.

[27] Department of Transportation, Federal Aviation Administration, *Occupational Safety and Health Standards for Aircraft Cabin Crewmembers* (Washington, D.C.: August 21, 2013).

[28] 14 C.F.R. § 121.359(g).

Table 1: Number of Selected Airlines That Allow or Provide Hearing Protection Equipment to Pilots and Flight Attendants for Use on an Aircraft in Operation, Based on Interviews of Airline Officials

Employee type	Policy[a]	Number of airlines (of 8)
Pilots	Allow earplugs	5
	Allow noise-reducing headsets	8
	Provide earplugs	5
	Provide active noise-reducing headsets[b]	2
Flight Attendants	Allow earplugs	5[c]
	Provide earplugs	4

Source: GAO analysis of information provided by airlines | GAO-18-109R

[a] In addition to providing hearing protection equipment, officials from two of the airlines said they make annual hearing tests available to crewmembers.

[b] In active noise-reducing headsets, sound is measured inside the headset and an opposite phase copy of the noise is fed back into the headset, cancelling each other.

[c] Officials from three of the airlines said they do not allow flight attendants to wear earplugs because they can diminish a flight attendant's ability to hear public address announcements. Officials from one of the airlines said that they provide and allow flight attendants to wear earplugs and only do so for flight attendants working on certain aircraft and during noisier flight segments.

Officials from three of the labor groups we interviewed said that they believe that the number of crewmembers who choose to use hearing protection is limited. Pilot labor groups told us that noise-reducing headsets can be costly or uncomfortable and that in some cases the aircraft communications systems are not compatible with such headsets.

Agency Comments

We requested comments on a draft of this product from the Department of Health and Human Services (HHS), the Department of Labor (DOL), and the Department of Transportation (DOT). HHS and DOL provided technical comments, which we incorporated as appropriate, and DOT had no comments.

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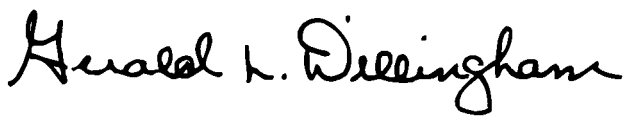
We are sending copies of this report to the appropriate congressional committees, the Secretary of Health and Human Services, the Secretary of Labor, and the Secretary of Transportation. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or dillinghamg@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 were Heather Halliwell (Assistant Director); Anne Doré (Analyst-in-Charge); Blake Ainsworth; Marcia Crosse; Alex Fedell; Jim Geibel; Dave Hooper; SaraAnn Moessbauer; Pamela Snedden; Madhav Panwar; Malika Rice; and Michelle Weathers.

Sincerely yours,



Gerald L. Dillingham, Ph.D.
Director
Physical Infrastructure Issues

Enclosures – 2

Enclosure I: Objectives, Scope, and Methodology

This report examines: (1) what is known about aircraft cabin and cockpit noise levels compared with occupational noise exposure standards and (2) selected airlines' policies on hearing protection for crewmembers.

To identify what is known about noise levels inside aircraft cabins and cockpits, we conducted a search of government, academic, and trade literature using terms such as "aircraft," "cabin," "noise," "decibel," "crew," and "sound," and asked the subjects we interviewed as part of this engagement whether they knew of any additional studies. From these searches, we selected 176 studies for further review. We further screened these studies to identify those that had likely conducted independent direct measurements of aircraft interior noise. We also screened the studies for reliability using the following criteria: (1) whether the study reported sound measurements in a useable format; (2) whether the study was conducted by an independent party (i.e., not an airline or aircraft manufacturer); and (3) whether the study used a recognized methodology for conducting measurements. These screening efforts yielded 10 studies. They were from a mixture of sources including academic journals, government agencies, and industry associations and varied in the techniques used to conducted measurements including taking measurements with fixed instruments while sitting in passenger seats and placing wearable dosimeters on flight attendants performing their duties.

To review the 10 studies we identified, we developed a data collection instrument designed to examine the studies' methodologies and major findings. Examples of study facets we examined included the number and type of aircraft measured; the method used to take measurements (e.g. a handheld sound level meter or a wearable dosimeter); the format used to report noise levels (e.g. an 8-hour time-weighted average or a simple mean average of measurements taken); the noise levels reported; and other relevant findings. (See enclosure II for a list of these studies and a detailed summary of their findings.)

The studies we reviewed varied in terms of methodologies used, aircraft types sampled, and format used to report results. While the studies mostly reported noise levels below occupational noise exposure standards, this variance does not allow us to determine interior noise levels present across the fleet of commercial aircraft operating in the United States.

To obtain information on the role of FAA and OSHA in overseeing aircraft interior noise levels, we reviewed FAA's and OSHA's laws, regulations and guidance pertaining to noise exposure, including FAA's 2013 policy statement on applying OSHA's occupational noise exposure standard in aircraft cabins, the 2014 memorandum of understanding that delineated FAA's and OSHA's role in implementing that policy, and FAA's aircraft certification rules and guidance related to interior noise. We also reviewed the occupational noise exposure standard from OSHA and the recommended occupational noise exposure limit from NIOSH and interviewed officials from FAA, OSHA, and NIOSH about the development, implementation, and enforcement of those standards.

We also interviewed a range of aviation entities that have knowledge of aircraft interior noise levels. These included officials from seven labor groups representing pilots and flight attendants who work on commercial aircraft, two aviation trade associations, and the four largest aircraft manufacturers. We also selected eight mainline and regional airlines that had the most passenger enplanements in the U.S. in 2016, the most recent available data, and that ensured that a wide range of aircraft types were included in our review. Information on noise level testing that we collected from our interviews with airlines and aircraft manufacturers could not be confirmed because the companies did not make the supporting documentation available to us,

citing its proprietary nature. Additionally, the information and perspectives that we obtained from these interviews may not be generalized to all industry stakeholders. (See table 2).

Table 2: Federal Agencies, Airlines, Industry Groups, Labor Groups, and Aircraft Manufacturers We Contacted or Interviewed

U.S. federal agencies
Department of Health and Human Services, National Institute for Occupational Safety and Health
Department of Labor, Occupational Safety and Health Administration
Department of Transportation, Federal Aviation Administration
U.S. mainline passenger airlines
American Airlines
Delta Airlines
Southwest Airlines
United Airlines
U.S. regional passenger airlines
ExpressJet Airlines
Horizon Air
Republic Airline
SkyWest Airlines
Industry groups
Airlines for America
Regional Airline Association
Airline labor groups
Air Line Pilots Association
Allied Pilots Association
Association of Flight Attendants
Association of Professional Flight Attendants
Coalition of Airline Pilots Associations
Independent Pilots Association
Teamsters Local 1224
Aircraft manufacturers
Airbus
Boeing
Bombardier
Embraer

Source: GAO. | GAO-18-109R

In addition, we reviewed an FAA analysis conducted in May 2017 on four of its safety and oversight databases to identify noise-related complaints made in the previous 5 years. We also evaluated data from the Aviation Safety Reporting System (ASRS), which is a safety database maintained by NASA for FAA, to identify reports made by pilots and flight attendants, among other aviation workers, of noise-related communications difficulties. We limited our search to these reports because FAA requires that aircraft noise in the cockpit does not interfere with the safe operation of the aircraft and that public address system announcements are audible by the cabin's occupants. To identify these complaints, we searched the ASRS for reports made between January 2012 and March 2017 and identified those that referred to communications challenges caused directly by aircraft interior noise, either from normal operations or malfunctioning equipment. We assessed the reliability of this dataset by reviewing our previous reliability assessments, which included reviews of documentation related to the data collection and storage and interviews with ASRS officials, and by confirming the continued validity of these earlier assessments by reviewing current ASRS documentation. In addition, we reviewed data

from the OSHA Information System on complaints made of aircraft cabin noise from August 2013, the year OSHA began receiving complaints related to aircraft interior noise, to May 2017, and for the same time period, we also reviewed data from the OSHA Information System to identify the total number of complaints submitted to OSHA from the passenger air transportation sector. To determine the reliability of these data, we interviewed officials and reviewed documentation from OSHA. From each of these sources, we excluded data that were related to noise concerns from malfunctioning aircraft equipment because while noise from such equipment may at times contribute to the crewmember's overall noise exposure, it does not represent normal operating conditions of aircraft. We also reviewed documentation related to OSHA's informal review of the complaints made about ambient aircraft noise. This documentation included information submitted by airlines, such as noise measurements that were taken by the manufacturers of their aircraft.

To identify airline policies on hearing protection for crewmembers, we asked officials from the selected mainline and regional airlines and airline labor groups to describe the types of hearing protection crewmembers are permitted to wear, any restrictions on their use, and other hearing related services, such as hearing tests, that are provided to crewmembers. We also asked these officials about the extent to which hearing protection and hearing-related services are used and what factors contribute to their use. The information and perspectives that we obtained from these interviews may not be generalized to all airlines or labor groups. In addition, we were not able to confirm the information officials from airlines provided us about their policies because not all of the airlines provided us with related documentation.

We conducted this performance audit from March 2017 to November 2017 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.

Enclosure II: Description of Studies Measuring Aircraft Interior Noise

We identified studies that reported noise levels measured inside aircraft cabins and cockpits by conducting our own literature searches using relevant terms and by asking the subjects we interviewed whether they knew of any additional studies. We screened the studies we identified from these sources using criteria such as whether the study reported sound measurements, was conducted by a neutral party, and used a recognized methodology for conducting measurements. The resulting 10 studies were from academic journals, government agencies, and industry associations, and varied in the techniques used to conduct measurements. For example, such techniques included taking measurements with static instruments while sitting in passenger seats and placing wearable dosimeters on flight attendants performing their duties. Table 3 summarizes the results of our review.

Table 3: Results of GAO's Review of 10 Studies That Measured Noise Levels in Aircraft Cabins and Cockpits

Study	Year	Location on aircraft measured	Measurement technique used	Type of aircraft measured	Number of flights measured	Results directly comparable to standards	Description of results
1	1994	Cabin	Fixed sound level meter	Boeing 727 and 757; McDonnell Douglas DC-9 and MD-80	35	No	This study reported that average cruise flight noise levels in each of the aircraft types measured were between 60 and 83 decibels.
2	2002	Cockpit	Acoustic mannequin	Airbus A320; Boeing 737-400, 747-100, 747-200, 747-400, 757-200, 767-300; McDonnell Douglas DC-10-30; British Aerospace ATP; Concorde	20	No	This study reported that noise levels, when averaged over the entire length of each flight, were between 70 and 77 decibels for each of the aircraft measured.
3	2007	Cabin and Cockpit	Fixed sound level meter and wearable dosimeter	Airbus A321 and others not reported	Not reported	NIOSH, but not OSHA.	This study reported that one measurement of noise levels during a full flight attendant work day on an unspecified long-haul aircraft was slightly below 85 decibels. The study also reported that one measurement of a pilot's noise exposure on a single flight aboard an unspecified short-haul aircraft was below 75 decibels. This study also reported measurements taken in the cabin on the A321during takeoff and climb were as high as 92.5 decibels during takeoff in a rear seat location.

Study	Year	Location on aircraft measured	Measurement technique used	Type of aircraft measured	Number of flights measured	Results directly comparable to standards	Description of results
4	2012	Cockpit	Fixed sound level meter	Airbus A319 and Bombardier DHC-8 Q400	2 (one for each aircraft type)	No	This study reported that the average noise levels inside the two aircraft cockpits measured were between 60 and 85 decibels for each of the phases of flight: pre-flight, taxi, takeoff, climb, cruise, descent, final approach and landing.
5	2008	Cabin and Cockpit	Not Reported	Airbus A330 and A340	6	No	This study reported that noise levels, when averaged over the entire length of each flight, were between 70 and 80 decibels in all areas of the aircraft measured.
6	2004	Cabin	Fixed sound level meter	Bombardier DHC-8 Q400, DHC-8 Q200, CRJ-700	18 (six for each aircraft type)	No	This study reported that median noise levels inside each aircraft type were between 75 and 85 decibels for each phase of flight (takeoff, cruise, and landing) except the rear seat position of the CRJ-700, which was reported at around 93 decibels on takeoff.
7	2006	Cabin	Wearable dosimeter	Avro RJ-85	20 flight attendant work days, but the exact number of flights was not reported.	OSHA and NIOSH	This study reported that noise levels experienced by individual flight attendants over full work days were not above the OSHA action level, but also that three of the work days likely exceeded the NIOSH recommended exposure limit.
8	2006	Cabin	Fixed sound level meter	Airbus A321	2	No	This study reported that the average noise levels in the cabin were between 58 and 80 decibels for each of the phases of flight: pre-flight, taxi, takeoff, climb, cruise, approach and landing, and parking.
9	2012	Cabin	Fixed sound level meter	Airbus A380; Boeing 737-300, 737-700, 747, 767, 777	83 (at least 5 per aircraft type)	No	This study reported that average noise levels in each of the aircraft types measured were between 67 and 76 decibels.
10	2004	Cabin	Fixed sound level meter	McDonnell Douglas MD-80	1	No	This study reported that 5-second average noise levels on the individual aircraft measured ranged from 87—99 decibels.

Source: GAO analysis of selected studies. | GAO-18-109R

The following are the 10 studies we reviewed, presented in the order as they appear in table 3.

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Mellert, V., I. Baumann, N. Freese, R. Weber. “Impact of sound and vibration on health, travel comfort and performance of flight attendants and pilots.” *Aerospace Science and Technology* 12 (2008): 18-24.

NIOSH, *NIOSH Health Hazard Evaluation Report: Horizon Air*, HETA#2002-0354-2931. Cincinnati, OH: February, 2004.

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Ozcan, H.K., S. Nemlioglu. “In-cabin Noise Levels During Commercial Aircraft Flights.” *Canadian Acoustics* Vol. 34 No. 4 (2006): 31-35.

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Spicer, C., M. Murphy, M. Holdren, J. Myers, I. MacGregor, C. Holloman, R. James, K. Tucker, R. Zaborski, *Relate air quality and other factors to comfort and health symptoms reported by passengers and crew on commercial transport aircraft (Part 1)*, American Society for Heating, Refrigerating, and Air Conditioning Engineers Project No. 1262-TRP. Atlanta, GA: July, 2004.

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