U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

December 9, 2020

The Honorable Roger Wicker
Chairman, Committee on Commerce,
Science, and Transportation
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

This letter transmits the Federal Aviation Administration (FAA) interim report to Congress required by section 326(d) of the FAA Reauthorization Act of 2018 (Public Law 115-254).

Section 326(d) directs the FAA to submit to the appropriate committees of Congress a report on the feasibility, efficacy, and cost-effectiveness of certification and installation of systems to evaluate bleed air quality. As part of the report requirements, Congress mandated FAA to commission a study by the Research in the Intermodal Transportation Environment-Airliner Cabin Environment Research (RITE/ACER) Center of Excellence (COE). FAA encountered challenges in re-assembling the partners of the COE, since the program was dissolved in 2014. On July 21, 2020, the FAA signed and issued a contract to universities that had previously made up the COE, effectively recreating the RITE/ACER partnership outside the COE system.

This interim report presents the research plan established to fulfill the original mandate required by section 326(c), as well as addresses the state of research and industry efforts to analyze cabin air in general.

We have sent identical letters to Chairman DeFazio, Ranking Member Cantwell, and Ranking Member Graves.

Sincerely,

Steve Dickson
Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

December 9, 2020

The Honorable Peter A. DeFazio
Chairman, Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

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800 Independence Ave., S.W.
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December 9, 2020

The Honorable Maria Cantwell
Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Cantwell:

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Administrator

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U.S. Department
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**Federal Aviation
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800 Independence Ave., S.W.
Washington, DC 20591

December 9, 2020

The Honorable Sam Graves
Committee on Transportation
and Infrastructure
House of Representatives
Washington, DC 20515

Dear Ranking Member Graves:

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This interim report presents the research plan established to fulfill the original mandate required by section 326(c), as well as addresses the state of research and industry efforts to analyze cabin air in general.

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FAA
Aviation Safety

REPORT TO CONGRESS:

Aircraft Air Quality

Interim Report

FAA Reauthorization Act of 2018 (Pub. L. No. 115-254) – Section 326(d)

Executive Summary

The Federal Aviation Administration (FAA) submits this interim report in response to section 326(d) of the FAA Reauthorization Act of 2018, Public Law 115-254, which requires the FAA to report on the feasibility, efficacy, and cost effectiveness of certification and installation of systems to evaluate bleed air quality. As part of the report requirements under section 326(d), Congress mandated FAA to commission a study by the Research in the Intermodal Transportation Environment-Airliner Cabin Environment Research (RITE/ACER) Center of Excellence (COE)[1] to:

1. Identify and measure constituents and levels on representative commercial aircraft.
2. Assess the potential health effects of constituents on passengers and flight crew.
3. Identify technologies suitable to provide reliable and accurate warning of bleed air contamination.
4. Identify potential techniques to prevent fume events.

The conditions and schedules mandated by section 326(c) of the FAA Reauthorization Act of 2018 could not be met directly, due in large part to the fact that the RITE/ACER COE had completed its mission and had "graduated" from the COE program in 2014, effectively dissolving the COE.[2] As a result, the FAA encountered procedural challenges in awarding contract work specifically to the RITE/ACER COE, since there was no longer an entity eligible for COE processes. To meet the intent of the Congressional mandate, on July 21, 2020 the FAA signed and issued a sole source contract to universities that had previously made up the COE, effectively recreating the RITE/ACER partnership outside the COE system. Now that the contract to re-establish the RITE/ACER partnership is complete, this interim report will present the research plan established to fulfill the original mandate required by section 326(c), as well as address the state of research and industry efforts to analyze cabin air in general.

Tasks Addressing Section 326(c):

Detection is the key to preventing bleed air contamination. The study will identify the contaminants of concern and a means of detecting them. The efficacy of current detection technology has received mixed reviews, and the length of this study accounts for the need to establish reliable detection capability. The FAA has established a cross-functional working group to review the research and provide direction to the new RITE/ACER partnership in completing this study to:

1. Assess the current state of knowledge.
2. Arrange industry collaborations.
3. Plan tests and develop instrument test packages.

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[1] See section on literature review (page 9) of this report for more information about RITE/ACER COE.

[2] The FAA's Office of Regulation and Certification established the ACER COE in 2004 to complete Congressional tasking. In 2014, the RITE/ACER COE completed tasks from section 815 of the Vision 100 – Century of Aviation Reauthorization Act, Public Law 108-176 (2003) thereby graduating from the FAA COE program.

4. Conduct tests.
5. Evaluate test results.
6. Conduct tests on aircraft and auxiliary power units (APUs) located at the FAA Technical Center in Atlantic City, NJ.
7. Evaluate aircraft and test stand data.
8. Determine health effects.

The FAA estimates the study will range in cost from $750,000 to $1,400,000 and take up to 54 months to complete. The cost and length ensure that the technology developed through this study is useful and reliable, and that the FAA addresses the public concerns on cabin air quality.

The FAA remains steadfast in its focus on safety of flight, and works with the appropriate U.S. Government agencies for guidance on public and occupational health to protect the traveling public. Historically, the FAA has issued regulatory standards for commercial aircraft environmental control systems, including ventilation, pressurization, and air conditioning systems. These standards prescribe requirements for manufacturers to design such systems to provide a safe environment for passengers and crewmembers.

In addition, the FAA has worked closely with airplane manufacturers, air carriers, and research institutes to study the cabin air quality of in-service aircraft in order to ensure a safe cabin environment. The FAA, European Union Aviation Safety Agency (EASA), and industry experts have conducted several studies that indicate the air quality of cabins on transport category airplanes is comparable to other forms of public transportation, and with public buildings and homes.

The FAA remains committed to fully addressing aircraft air quality concerns in response to section 326(d) and is currently engaged in several actions to address those concerns. The FAA will submit a final report on section 326(d) after the necessary research is completed.

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Introduction

This interim report is provided in response to the legislative requirements established in the FAA Reauthorization Act of 2018, Public Law 115-254, section 326, Aircraft Air Quality. Section 326(d) of specifies:

"Not later than 18 months after the date of enactment of this Act, the Administrator shall submit to the appropriate committees of Congress a report on the feasibility, efficacy, and cost-effectiveness of certification and installation of systems to evaluate bleed air quality."

The FAA based this interim report on multiple data sources and references, including but not limited to FAA regulations and advisory circulars, aerospace industry consensus standards, recommended practices and information reports, proprietary design information from manufacturers, FAA and Foreign Civil Aviation Authorities technical reports, and peer-reviewed academic research.

The FAA commissioned a new study, based on the legislative requirements established in section 326(c), to identify bleed air contaminants. The FAA will submit a final report on section 326(d) after the necessary research is completed.

Background

Regulatory History

Federal regulations governing the cabin environment of large commercial, transport category airplanes are codified under title 14, Code of Federal Regulations (14 CFR) 25.831, "Ventilation," 25.832, "Cabin ozone concentration," and 25.841, "Pressurized cabins." Together, these three regulations provide the minimum standard that manufacturers of large transport category aircraft (i.e., aircraft of more than 12,500 pounds maximum certified takeoff weight operated by an air carrier) must meet.

Federal regulation at § 25.831, "Ventilation," require that the ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable crewmembers to perform their duties without undue discomfort or fatigue, and to provide reasonable passenger comfort during normal operating conditions and after the probable failure[3] of any system that would adversely affect the flight deck or cabin ventilation air. Of special note are the requirements within § 25.831 for ventilation airflow per occupant specifying 10 cubic feet per minute (cfm) or 0.55 pounds of fresh air per minute, and carbon dioxide (CO_2) concentration limits during flight not to exceed 0.5

[3] Probable failure conditions are those anticipated to occur one or more times during the entire operational life of each airplane. Probable failure conditions have a probability of occurring greater than the order of 1×10^{-5}.

percent by volume (sea level equivalent). In addition, the regulation states carbon monoxide (CO) concentrations in excess of 1 part in 20,000 parts of air are considered hazardous. While § 25.831 does not contain a specific oxygen requirement, 10 cfm of fresh air ventilation provides more oxygen than is necessary for respiration while carrying out normal activities. While the hazardous nature of CO and CO_2 are known from many sources, the FAA selected levels that are appropriate to the airplane environment.

The FAA adopted § 25.832, "Cabin ozone concentration," following complaints from crewmembers and passengers about various adverse health effects associated with ozone gas (O_3) in airplane cabins. Ozone gas can be irritating to the respiratory tract and eyes when present in high enough concentrations. Because the level of discomfort is proportional to the level of activity of the parties exposed, cabin attendants are more likely to be adversely affected. The ozone limits in § 25.832 are intended to protect passengers and crewmembers from exposure to concentrations high enough to be hazardous.

Section 25.841, "Pressurized Cabins," provides standards for pressurized compartments in transport category airplanes and addresses the requirements for various controls and pressure relief valves. Testing required for demonstrating compliance with many of the requirements of § 25.841 is addressed in § 25.843, "Test for pressurized cabins."

For transport category airplanes, the FAA requires manufacturers to demonstrate compliance with §§ 25.831, 25.832, and 25.841 to show that the airplane crew and passenger compartment air is free from harmful or hazardous concentrations of gases and vapors. Manufacturers must also show the airplane environmental control system enables the crewmembers to perform their duties without undue discomfort or fatigue, and that the system provides a reasonable passenger environment.

Air carriers are required by 14 CFR 121.703, "Service difficulty reports," to file a service difficulty report on any failure, malfunction, or defect that results in smoke, vapor, or toxic or noxious fumes in the flight deck or cabin during flight.

The FAA, manufacturers, and air carriers currently maintain cabin air quality by defining appropriate design standards, designing the environmental control systems to meet those standards, and conducting proper maintenance, respectively. The FAA has worked closely with airplane manufacturers, air carriers, and research institutes to study the cabin air quality of in-service aircraft in order to ensure a safe cabin environment.

Sources of Contaminants

Cabins and flight decks are in the pressurized section of the airplane fuselage. Air quality within the cabin/flight deck can be affected by both externally sourced contaminants (ESCs) and internally sourced contaminants (ISCs). These contaminants can enter the environmental control system for ventilation, pressurization, and temperature control of the airplane. While section 326(c) of the FAA Reauthorization Act of 2018 focuses on air contaminants from external sources, the FAA addresses air contaminants from internal sources in this report as well.

ESCs can enter the cabin/flight deck from an engine or APU and may include contaminants from outside the airplane (e.g., deicing fluid, engine/APU lubricating oil, volcanic ash, etc.).[4] In addition, ISCs are present in the cabin/flight deck (e.g., occupants, electronics, food and drink, carry-on bags, etc.). The following table identifies ESCs and ISCs, and the associated contaminants (e.g., gaseous components, particulate, etc.).

Table 1: Types of ESCs and ISCs Contaminants

Externally Sourced Contaminants (ESCs)	Internally Sourced Contaminants (ISCs)
Engine/APU oil can result in CO, particulates, and other chemicals (e.g., tri-o-cresyl phosphate (TOCP), formaldehyde, and acetaldehyde). Engine oil ingestion tests have shown that small quantities of these chemicals can enter the engine bleed system. However, the observed concentration of these chemicals have been below the OSHA permissible exposure limits (PEL).[5]	**Occupants** produce CO_2 and can be a source of bio effluents, volatile organic compounds (VOCs), pet dander, pet hair, scents/odors, viruses, bacteria, allergens, and fungal spores.[6] In addition, tests conducted previously by the RITE/ACER COE have shown that occupant skin oil interaction with ozone and UV radiation can produce irritants.[7] RITE/ACER COE concluded that ozone-oxidation products "...may contribute to the complaints of mucous membrane irritation (e.g., irritated eyes and throat) commonly reported by the flying public."
Hydraulic fluid when heated can result in CO, acrolein, formaldehyde, acetaldehyde, particulates, and other chemicals (e.g., Tributyl phosphate (TBP) and toluene). The National Research Council reported that hydraulic fluids may contain as much as 1%	**Cabin furnishings** can release formaldehyde, VOCs, semi-volatile organic compounds (SVOCs), particulates, and are treated with flame retardants that can release organophosphates as reported by the National Research Council.[4] In addition, interaction with ozone can produce irritants.

[4] Compressed air called bleed air is extracted from propulsion engine compressors and supplied to one or more air-conditioning "packs," where it is further compressed, cooled, and then expanded in a rotating air-cycle machine to produce low-temperature air that is supplied to the aircraft cabin.
[5] David R. Space, Anil K. Salgar, Dale A. Scheer, Byron W. Jones, Ph.D., P.E., Fellow ASHRAE, Shahin Nayyeri Amiri, Ph.D., "Experimental Determination of the Characteristics of Lubricating Oil Contamination in Bleed Air," LV-17-C047, presented at the ASHRAE Winter Conference January 28 through February 1, 2017.
[6] National Research Council, "The Airliner Cabin Environment and the Health of Passengers and Crew," ISBN: 0-309-56770-X, 2002.
[7] William W. Nazaroff and Charles J. Weschler, Report No. RITE-ACER-CoE-2010-2, "Ozone in Passenger Cabins: Concentrations and Chemistry," Final Report, August 2010.

TOCP[4] [neurotoxic isomer tri-o-cresyl phosphate (TOCP)].	
Deicing fluid used on airplanes typically contains propylene glycol. Pyrolysis of propylene glycol can result in CO, hydroxyacetone, acetaldehyde, formaldehyde, acrolein, and other constituents.[8]	**Electrical equipment** may contain polychlorinated biphenyls (PCBs) per the Environmental Protection Agency (EPA) (e.g., transformers, capacitors, voltage regulators, switches, insulation, fluorescent light ballasts, etc.).[9] Fires to energized electrical equipment could release vapors from burning PCBs as well as byproducts of combustion (e.g., polychlorinated dibenzo-p-dioxins).
Aircraft and car traffic at the airport per the EPA produce exhaust gases (e.g., CO, CO_2, NO_X, O_3, SO_2, jet fuel and gasoline vapors, particulates (PM-2.5, PM-10)) that enter the airplane during times when crewmembers and passengers are entering and exiting of the airplane.[10]	

In addition, behavioral psychology can influence the perception of air quality on commercial airplanes. Some passengers suffer from anxiety when traveling. "After anxiety induction, neutral smells become clearly negative. . . . People experiencing an increase in anxiety show a decrease in the perceived pleasantness of odors."[11] In addition, some people may experience "phantosmia," the medical term for an imaginary odor (i.e., a phantom smell). It is also known as an "olfactory hallucination." This perceived smell is unique to each person and is usually unpleasant, spoiling the taste of any food or drink consumed. Phantosmia may occur due to upper respiratory infection (e.g., inflamed sinuses).

Literature Review

The FAA, EASA, and industry experts have conducted several studies that indicate that the air quality of transport category airplane cabins is on par with other forms of public transportation, and with public buildings and homes.

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[8] Robert Paul Jensen, "Thermal Decomposition of Electronic Cigarette Liquids" (2016). Dissertations and Theses. Paper 3081. Portland State University.
[9] United States Environmental Protection Agency (EPA) Learn about Polychlorinated Biphenyls (PCBs), https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs.
[10] United States Environmental Protection Agency (EPA) designated nonattainment areas for all National Ambient Air Quality Standards (NAAQS), https://www.epa.gov/green-book.
[11]Elizabeth A. Krusemark, Lucas R. Novak, Darren R. Gitelman, Wen Li, "When the Sense of Smell Meets Emotion: Anxiety-State-Dependent Olfactory Processing and Neural Circuitry Adaptation." The Journal of Neuroscience (JNeurosci). September 25, 2013. 33(39):15324–15332. doi:10.1523/JNEUROSCI.1835-13.2013.

In 2004, in response to section 815 of the Vision 100 – Century of Aviation Reauthorization Act, Public Law 108-176 (2003), the FAA established a National Center of Excellence (COE) for Airliner Cabin Environment Research (ACER), which in 2007 was broadened and renamed to the National Air Transportation COE for Research in the Intermodal Transport Environment (RITE/ACER). The Congressional mandate tasked RITE/ACER COE to conduct research to address the topics: Ozone, Cabin Pressure, Outside Air, Air Quality Incidents, Pesticide Exposure, and Relative Humidity. The COE operated from 2004 – 2014, producing numerous scientific publications, including RITE/ACER and FAA technical reports. In 2014, the RITE/ACER COE completed its tasks and successfully met all requirements; thereby graduating from the FAA COE program. Reports of research conducted by the RITE/ACER COE are available at the FAA Civil Aerospace Medical Institute (CAMI) medical library website.[12]

In response to section 917 of the FAA Modernization and Reform Act of 2012, the FAA assessed cabin air quality, including the identification and measurement of oil-based contaminants, an assessment of bleed air on aircraft, and the identification of health risks following exposure. In December 2015, the FAA published a report describing the potential health-related risks surrounding human exposure to bleed air contaminants generated during fume events inside pressurized aircraft.[13] The report cites the rare occurrence of air quality events in aircraft flight decks and cabins. As stated in the report, the FAA found that the rate of cabin air quality events is estimated to range in occurrence from 2.7 to 33 events per million aircraft departures. The lower end of this range was determined from a comprehensive survey of service difficulty reports reviewed by a broad team of subject matter experts within the FAA, and is generally on the order of magnitude considered to be “rare” and in line with FAA expectations. The higher end of the range represented the findings from reports originating outside the FAA, for which the raw source of report was uncertain. The range thus represents a conservative estimate of cabin air quality event rate.

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[12] Website of the Civil Aerospace Medical Institute Library: https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/cami/library/online_libraries/aerospace_medicine/

[13] Civil Aerospace Medical Institute Library, “Aircraft Cabin Bleed Air Contaminants: A Review”. November, 2015 (https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201520.pdf).

Response to Section 326(d) Requirements

The FAA remains committed to addressing aircraft air quality concerns, and is currently engaged in several actions to address those concerns.

As part of the report requirements under section 326(d), research information is needed from section 326(c) tasking the FAA to commission a study by the RITE/ACER COE to:

1. Identify and measure constituents and levels on representative commercial aircraft.
2. Assess the potential health effects of constituents on passengers and flight crew.
3. Identify technologies suitable to provide reliable and accurate warning of bleed air contamination.
4. Identify potential techniques to prevent fume events.

The FAA agrees with the objective to provide pilots with improved awareness regarding system failures that result in smoke/fume/odor events. The remainder of this report describes the FAA actions completed to date, and those pending completion, in compliance with the requirements of section 326(d), as well as actions completed and pending completion by the aviation industry concerning cabin air quality.

Section 326(c) Research

On December 11, 2018, the FAA contacted RITE/ACER representatives to address section 326(c) of the FAA Reauthorization Act of 2018. The United States government shutdown from December 22, 2018, until January 25, 2019 caused a delay following initial contact. From February 8, 2019, to April 30, 2019, representatives of RITE/ACER universities defined a scope of activities with representatives from FAA Aircraft Certification Service (AIR), Aerospace Medicine (AAM), and the William J. Hughes Technical Center (ANG) offices to address the requirements. The FAA seeks to leverage this opportunity to go even beyond the statutory mandate in studying the issues presented.

The FAA and the United Kingdom Civil Aviation Authority (UK CAA) tasked R.G.W. Cherry & Associates Limited to collect and analyze data relating to in-service occurrences involving fire, smoke, or fumes on U.S.-registered aircraft.[14] The appendices of this report present some of the results of that study. Specifically, figures 1-3 show that a majority of reports of smoke, fume, and odor events on commercial airplanes result from ISCs rather than ESCs. Furthermore, the full report provides supporting information that limiting cabin and flight deck air quality concerns associated with smoke, fume, and/or odor events to only those from ESCs would not capture the majority of smoke, fume, and/or odor events on commercial airplane operations.

[14] DOT/FAA/TC-16/49, "Research into Fire, Smoke or Fumes Occurrences on Transport Airplanes," Final Report, March 2017, https://www.fire.tc.faa.gov/pdf/TC-16-49.pdf.

Detection is the key to preventing bleed air contamination. The study will identify the contaminants of concerns and a means of detecting them. The efficacy of current detection technology has received mixed reviews, and the length of this study accounts for the need to establish reliable detection capability. The FAA has established a cross-functional working group comprising specialists from AIR (Lead), AAM, and ANG to review the research, and provide direction to the RITE/ACER partnership in completing this study.

FAA tasks for addressing Section 326(c):

1. Assess current state of knowledge.
2. Arrange industry collaborations.
3. Plan test stand tests and develop instrument test packages.
4. Conduct test stand tests.
5. Evaluate test stand results.
6. Conduct tests on APUs located at the FAA Technical Center in Atlantic City, NJ.
7. Evaluate aircraft and test stand data.
8. Determine health effects.

The FAA estimates the study will range in cost from $750,000 to $1,400,000 and take up to 54 months to complete. The cost and length ensure that the technology developed through this study is useful and reliable, and that the FAA addresses the public concerns on cabin air quality. The FAA has identified agency and partner assets (e.g., ground-based aircraft) to support the study. The FAA will not require the optional pilot program described in section 326(e) because it adds significant time and cost to the study and duplicates industry activities.

The FAA encountered two procedural challenges in identifying the correct vehicle for assigning and paying for work to the RITE/ACER COE, which delayed initiating a contract:

- The RITE/ACER COE graduated from the COE program and is no longer eligible for COE processes.
- The previous people and organizations that made up the COE are no longer in the same alignment. Some key personnel have changed employment status.

To meet the intent of the Congressional mandate, the FAA initiated a sole source contract to Kansas State University, which will subcontract to Auburn University and Boise State University as needed. This action effectively recreated the RITE/ACER partnership outside the COE process, but at the cost of significant delays in contract award.

In addition, concurrently with the outlined research with Kansas State (and Auburn University and Boise State University), the FAA began a much smaller study within the William J. Hughes Technical Center (ANG) Fire Safety Branch to test selected ISCs. The FAA expects to conclude this study in Fiscal Year 2023.

Aviation Industry Actions of Interest on Cabin Air Quality

Furthermore, the aviation industry has been expending resources to address smoke/fume events on aircraft, and the activities outlined in this section are ongoing. Over servicing of engine/APU oil levels can result in air contaminants entering the engine/APU bleed producing odors in the cabin and flight deck. Some airline operators have changed, with the assistance of engine/APU manufacturers, their maintenance procedures to check oil level between flights to reduce the potential to over service engine/APU oil.

In January 2018, the FAA participated in meetings with the Airlines for America (A4A) Cabin Air Quality Task Group (CAQTG), which consists of members of A4A, manufacturers, labor unions, research groups, and other airline interests. The purpose was to understand the nature of the problem, develop collaborative approaches, and manage cabin air quality issues. The CAQTG identified a number of goals, including developing procedures for effectively following up on reported events, creating common terminology for reports/data collection, working with training providers to better identify certain smells/fumes, and working with other stakeholders for further research. The FAA continues to participate in the A4A CAQTG.

Similarly, in April 2018, the FAA saw the release of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Research Project Report 1262-RP, "Relate Air Quality and Other Factors to Comfort and Health Related Symptoms Reported by Passengers and Crew on Commercial Transport Aircraft (Part 2)" that ASHRAE and the FAA co-sponsored. This research activity collected data from revenue flights operated by three airlines. Occupant surveys were collected from passengers and crewmembers. Additionally, cabin air quality environmental data were measured, including levels of O_3, CO_2, CO, ultrafine particulate, air cabin temperature, cabin relative humidity, cabin pressure, and cabin sound. The results showed the flight deck and cabin provide a safe and comfortable environment. The FAA continues to support ASHRAE-sponsored research on CO_2 and VOC at typical cabin pressure altitudes, and their potential impact on cognitive performance.

In addition, SAE International created the Cabin Air Quality Measurement Committee (AC-9M) with the responsibility for creating and maintaining standards for the measurement of air quality within the flight deck and passenger compartments. The initial project will focus on developing a standard or standards covering portable sensors to quantitatively measure fumes and contaminants that could enter the cabin space. Since 2017, FAA specialists have been supporting the SAE AC-9M committee (Subgroup E) in developing a standard (Draft AS6923) for measuring devices/systems for maintenance troubleshooting of cabin air issues on commercial aircraft. The intent of this work is to assist airplane maintenance personnel to identify more accurately the sources of contaminants.

Lastly, the FAA is supporting the ASHRAE-Industry CognitAir research program. This study is evaluating the combined effects of CO_2 concentration, certain VOC likely to be present on airplanes during failure conditions, and cabin altitude on cognitive performance. Analysis of the data is currently in progress.

Aviation Industry Response to FAA Questionnaire on Feasibility, Efficacy, and Cost-Effectiveness of Systems to Evaluate Bleed Air Quality

The FAA requested that airplane manufacturers provide information relative to the research associated with section 326(c) of the FAA Reauthorization Act of 2018. The FAA collected industry information on technologies to effectively monitor the aircraft air supply and provide reliable and accurate warnings of air contamination. The FAA requested the assistance of four major airplane manufacturers to understand better the feasibility, efficacy, and cost-effectiveness of certification and the installation of systems to evaluate bleed air quality. The FAA requested the manufacturers address contaminants from sources external to the pressurized vessel (e.g., from engine/APU oil, hydraulic systems, deicing fluid, etc.), as well as those within the pressurized vessel from internal sources (e.g., electrical component failures, offensive odors from galleys and lavatories, etc.). Three of the four manufacturers provided responses.

The consensus position of industry is that any detection system must provide accurate and reliable information to ensure pilot situational awareness and an appropriate response by flight crew and maintenance personnel. Two of the manufacturers conducted initial studies to determine the potential feasibility of sensor systems to determine cabin air quality, and one manufacturer conducted limited flight tests to gain experience with sensor operation. However, to date, no manufacturer has completed any study of the efficacy, reliability, or maintainability of these sensors, or provided cost-effectiveness data. Manufacturers contend that an acceptable cost-to-benefit ratio should be demonstrated before the FAA mandates installation of contaminant sensors on their airplanes.

In summary, some airplane manufacturers have been studying the technology available to detect a limited number of contaminants that could be present during normal operation and after some system failures, but they believe additional work must be accomplished to demonstrate the long-term cost-benefit for their installation. In addition, manufacturers are either participating in, or aware of, the industry group activities (e.g., A4A CAQTG, ASHRAE-Industry CognitAir research program, SAE AC-9M, etc.), and they expressed support for section 326(c) research.

Conclusion

The FAA remains committed to addressing aircraft air quality concerns and is currently engaged in several actions to address them. The FAA has worked closely with airplane manufacturers, air carriers, and research institutes to study the cabin air quality of in-service aircraft in order to ensure a safe cabin environment. The FAA, EASA, and industry experts have conducted several studies that indicate that the air quality of cabins on transport category airplanes is equivalent to other forms of public transportation, as well as public building and homes. The FAA finds that the key to preventing fume events resulting from bleed air contamination is early detection of system problems and preventive maintenance procedures.

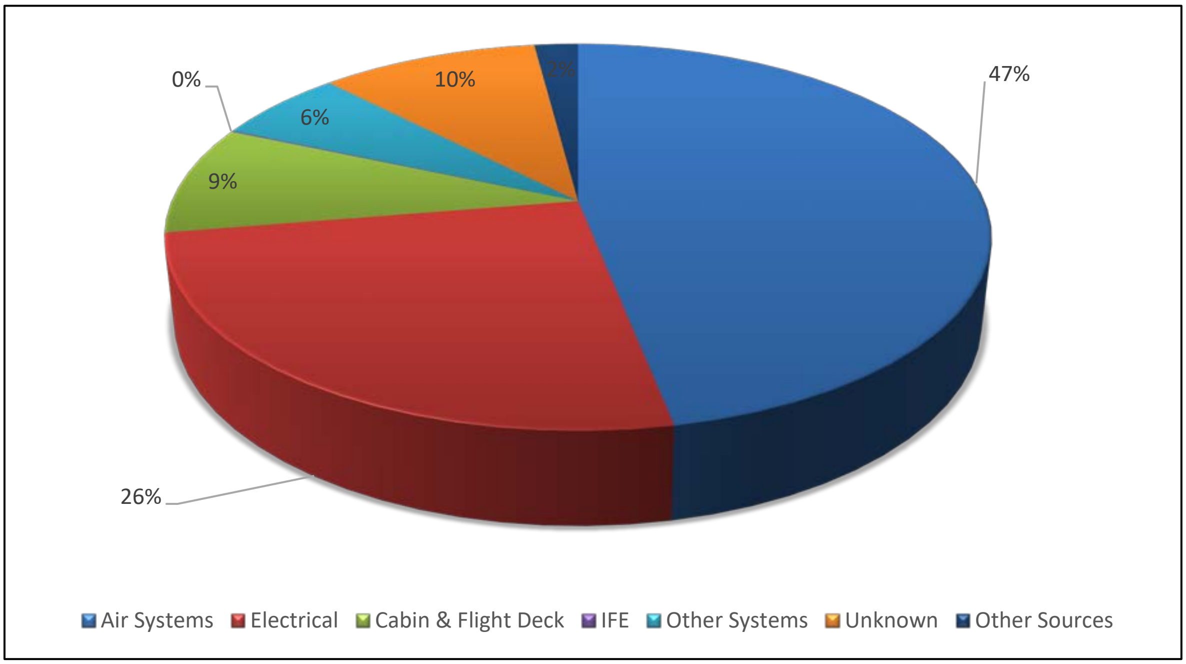
The FAA supports providing pilots with improved situational awareness regarding system failures that result in smoke/fume/odor events, as intended by section 326(c) of the FAA Reauthorization Act of 2018. The FAA maintains that the strategy we are pursuing, and our support of industry activities, effectively responds to public concerns on cabin air quality.

Appendices

Supporting Data: Cabin Air Quality Events

The FAA recreated figures 1, 2, and 3 from data presented in DOT/FAA/TC-16/49, "Research into Fire, Smoke or Fumes Occurrences on Transport Airplanes," Final Report, March 2017.[15] The figures show the sources of fire, smoke, or fume events in occupied areas for regional, narrow body, and wide body passenger airplanes, respectively. This breakdown of smoke, fume, and odor sources by system covers the entire period analyzed in the study (i.e., 2002 through 2014). Air systems were defined as those containing all components of engines, APU, the engine/APU bleed system, and air conditioning systems. Electrical systems include cabin and flight deck emergency lighting systems.

Figure 1: Sources of Fire, Smoke, or Fume in Regional Passenger Airplanes



[15] Research into Fire, Smoke or Fumes Occurrences on Transport Airplanes Report: https://www.fire.tc.faa.gov/pdf/TC-16-49.pdf.

Figure 1: Sources of Fire, Smoke, or Fume in Narrow Body Passenger Airplanes

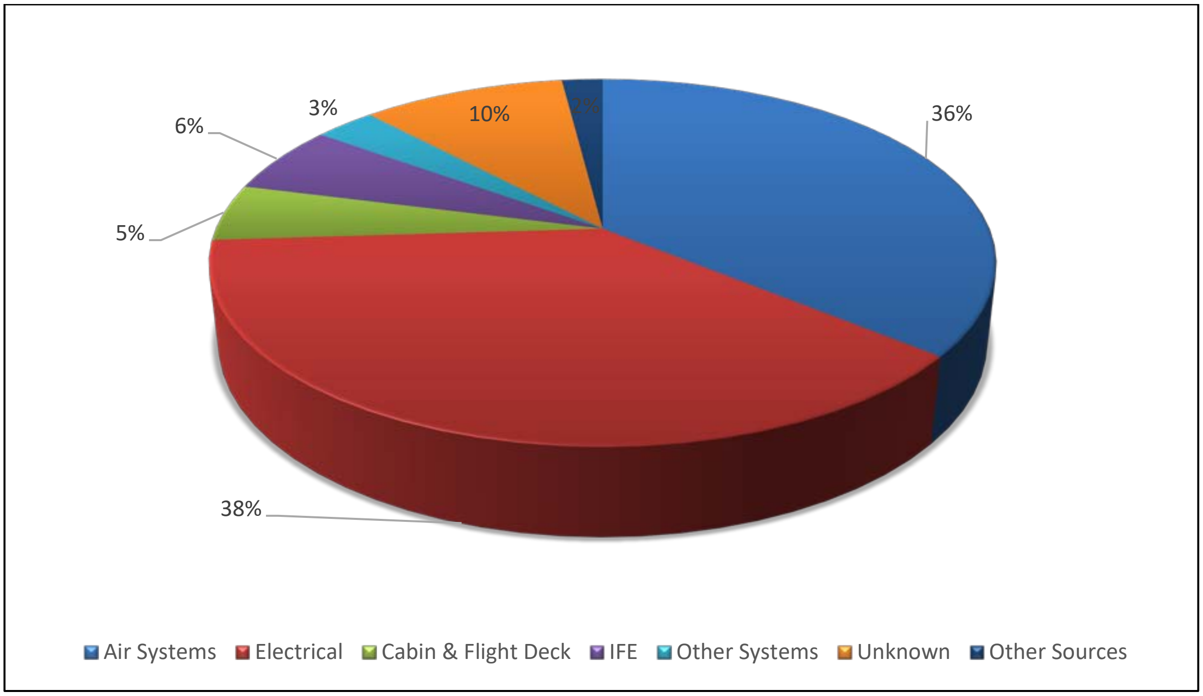
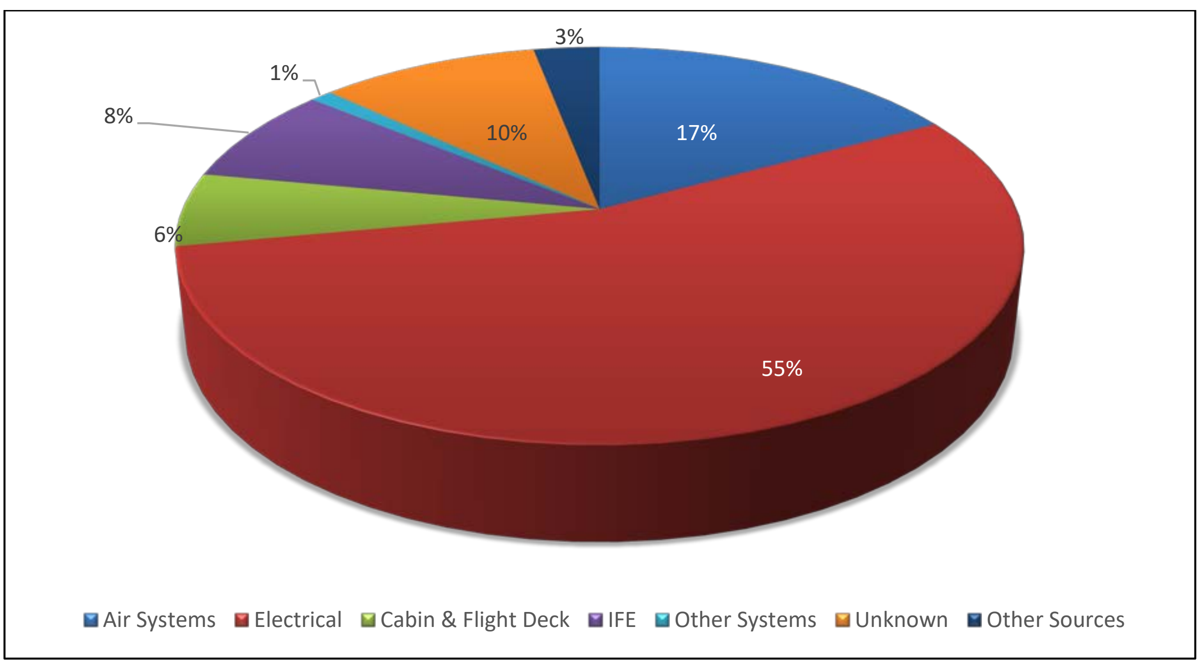


Figure 2: Sources of Fire, Smoke, or Fume in Wide Body Passenger Airplanes



As this approach is a system assessment, it is useful in categorizing data at a high level, but does not provide sufficient depth to identify root cause in all events. These figures indicate that limiting cabin and flight deck air quality concerns associated with smoke, fume, and/or odor events to only those from ESCs would not capture the majority of smoke, fume, and/or odor events on commercial airplane operations.