



Center Highlights

As of March 23, 2007

1 Ozone

ACER's ozone project aims to answer the following questions:

- Are cabin ozone levels compliant with current Federal regulations?
- What is an appropriate limit for cabin ozone, such that this is compatible with the health of passengers and crew?

ACER is therefore conducting a research program that currently comprises three coordinated tasks: (1) in-flight measurements of cabin ozone levels on routine flights; (2) laboratory research on the chemical interactions between ozone and materials found in the cabin environment; and (3) experiments with human subjects in a simulated section of an aircraft cabin, investigating the chemistry plus the physiological and perceived effects of ozone.

ACER's ozone project is well underway. As of February 2007, in-flight measurements have been completed on 45 of the 75 flights planned. Almost all flights have shown average ozone levels below the current 100 ppb limit. Ozone levels are considerably lower on aircraft equipped with ozone converters than on those without this control device. It is important to note that, not only is ozone significant in its own right, but the byproducts of ozone-initiated chemistry also raise concerns for the health of passengers and crew. Laboratory experiments have been completed investigating ozone interactions with the most common materials in the cabin, including seat fabric, carpeting, and the plastic materials used for overhead storage bins and wall coverings. Ozone reactions with common clothing fabrics have also been studied. For most materials, significant rates of reaction have been observed, generating reaction products that are known to be toxic or irritating. Experiments with human subjects in the simulated cabin indicate that ozone levels similar to those encountered in-flight produce some degradation in the perceived cabin air quality and also exacerbate some symptoms commonly associated with what is referred to as sick-building syndrome.

With the help of ACER's industry partners, we are considering whether technological solutions are available that could reduce both ozone levels and maintenance costs for the airlines.

The bottom line thus far: Cabin ozone levels are mostly, but not always, within allowed limits, but significant issues remain with the appropriateness of these limits. Work on testing technology solutions is in the planning stage.

2 Pesticides

ACER's pesticides project aims to determine whether the use of chemical pest control (disinsection) practices represents a threat to the health of passengers and crew. This study therefore encompasses information gathering on pesticide application practices, laboratory measurements, field sampling, modeling and, to a limited extent, studies on biomarkers of pesticide exposure.

Routine pesticides application is only required in a limited number of countries outside the US but may be used within the US and other countries to address specific problems on aircraft. Hence full information on disinsection practices is not readily available. ACER has therefore undertaken a survey of disinsection practices outside the US and this is well underway. Simultaneously, preparations are ongoing to allow forthcoming measurements of pesticide levels on board airliners and samplers have been prepared and calibrated. Modeling work is also underway. Information on when residue spraying has been done on specific aircraft has not been accessible to date. Plans to include pesticide measurements now exist within the joint effort between ACER and Battelle as part of a recently awarded grant from ASHRAE. This will provide information on the prevalence of measurable pesticide levels on the general aircraft fleet.

The bottom line thus far: On track, but too early for definitive results.

3 Pressure

The FAA regulates air pressure in the cabin environment. However, there are limited data on the physiological effects of cabin air pressure. ACER has therefore been tasked by the FAA with evaluating the current state of knowledge on cabin pressure effects, recommending next steps in terms of experimental studies and then undertaking these experimental studies.

Last year, a panel with expertise in pulmonary physiology, neuro-cognitive response, cardiology and aerospace medicine was assembled to review the current literature and existing studies related to the physiological and cognitive responses to a reduced partial pressure of oxygen (pO₂) in healthy adults. The panel's review, through two panel meetings and many smaller interactions has produced the following:

- ❑ specific feedback on the recent Boeing – Oklahoma State University study;
- ❑ identification of gaps in scientific understanding;
- ❑ plans to address these gaps through several study designs;
- ❑ A proposal and subsequently the receipt of funding for selected studies focusing on the health effects on compromised populations and working in partnership with the

FAA's Civil Aerospace Medical Institute (CAMI).

The panel is now finalizing its report on the state of the literature. Panel members have been developing the study to be conducted together with CAMI. In particular, attention has been paid to exploring the utilization of the optimal technologies for physiological measurements.

The bottom line thus far: Work is currently underway to begin the exploration of gaps in understanding through chamber studies on compromised populations at CAMI.

4 Incidents and Filter Study

Rare instances of "smoke in the cabin" type air quality incidents have been reported. At least a portion of these may be associated with contamination of the bleed air, drawn from the compressor stages of the engines. It has been claimed by some of the crew associations that contaminated bleed air is inducing severe neurological symptoms in some cabin crew members.

In response to this concern, ACER is conducting a research program on air quality incidents. A portion of this program has linked statements of work between ACER and another organization (OHRCA). This portion of the work focuses on sampling to detect bleed air contamination and the establishment of an air quality reporting system. ACER is also analyzing the HEPA filters used in the air return system on many aircraft in an effort to determine if these provide an "archive" of data on past cabin air quality events.

Preparations continue for the incidents study. Work on methods to document and analyze flight attendant experiences is progressing and the initial stages of this have been completed and other preparations are ongoing. Post-service HEPA filter samples have been obtained and analysis of these is well underway, with the intent of obtaining information on any air-quality incidents that may have occurred (these are rare and hence the chances of detecting these with samplers on any given flight is small; surveying the filters provides a potential workaround).

The bottom line thus far: Progress has been made with preparation for the incidents study. Analysis of retrieved filters is well underway.

5 In-Flight

Characterization of the current cabin environment is a key element of any program on cabin air quality. ACER is therefore undertaking a detailed program of in-flight measurements. ACER has sought non-Federal cash co-funding of this program and a joint proposal submitted by Battelle and ACER for ASHRAE funding was successful. Contract negotiations are currently underway and as soon as these are complete, the in-flight program will commence.

The bottom line thus far: Work will commence in the next few months.

6 Contaminant Transport

A thorough understanding of how contaminants travel through the cabin environment is needed to support almost all of ACER's research. ACER is therefore undertaking a detailed research program of contaminant transport modeling and experimental verification of the models.

Very significant progress has been made with modeling the transport of contaminants, including airborne pathogens and chemicals. These models support and enable most other ACER activities. For example, models constructed to date predict where pathogens emitted by a coughing passenger will end up in the cabin; where best to locate sensors; and the effect of coughing passengers walking down a cabin aisle on the distribution of contaminants. A 10 seat row cabin mockup for validating the models has been constructed and tested. This mockup is now fully equipped with seats, occupied by thermal mannequins that simulate the heat-load generated by a fully occupied cabin. Commissioning of the 10 row mockup has commenced and work on validating the models using the mockup has commenced. Initial verification using a smaller (4 seat row) mockup has indicated that the models generate accurate predictions.

The bottom line thus far: Models of chemical and pathogen transport have been developed. Initial testing confirms that the models that have been developed so far are valid.

7 Sensors

ACER has been tasked by the FAA with determining the feasibility of deploying commercial off-the-shelf (COTS), government off-the-shelf (GOTS), or near-market (NM) sensors to detect biological or chemical agents and if possible, the spread of pathogens during an epidemic/pandemic. ACER has also been tasked with characterizing COTS environmental air quality sensors for use in the in-flight measurements project.

Following completion of a comprehensive technology downselection exercise for 100 chemical and biological (chem.–bio.) sensors, plus numerous related systems, work has commenced on testing the leading candidate sensors. Access to these is through loan from ACER's industry partners, collaboration with the Edgewood Chem. Bio. Center (ECBC) and where necessary, purchase. Although experimental work is still in progress, some preliminary results have been obtained that challenge the applicability of laboratory performance data to the conditions likely to be encountered in the field. Indeed, the intent is that ACER will focus on practically achievable performance goals and hence develop a workable, affordable solution, with attainable, if limited goals. Simultaneously, a sensor backbone system developed by ACER to enable the use of sensors throughout the cabin is on its third iteration and in its present form is more compact, runs on lower power and costs less than the previous generation ACER backbone system (ACER is having to use coins as size markers and the building blocks of the third generation sensor backbone sys-

tems are priced generally at < \$ 50). Work on where best to locate sensors has defined how to obtain the greatest amount of pertinent information by the use of just a few sensors (to minimize cost) and it has been found that even a single sensor can provide useful data, if suitably positioned.

The bottom line thus far: The sensor technology downselect has been completed and candidate sensors are being characterized presently. The sensor backbone, now in its third generation, is smaller, better and cheaper than the last version. Optimum sensor locations have been identified to control system cost while maximizing performance.

8 Decontamination

Decontamination of the airliner cabin represents a potential response to both chem.–bio. terrorism and epidemics/pandemics in which civil aviation could be a key vector. ACER has been tasked by the FAA with conducting an evaluation of the efficacy, materials compatibility and practicality of delivery of whole airliner decontamination, within the logistics, safety climate and fiscal constraints of civil aviation. This work includes full-scale decontamination demonstrations.

A decontamination technology downselect has been completed. Field evaluation of the AeroClave thermal decontamination system using a DC-9 has also been completed. This has been supported by efficacy results in the laboratory. Addition of STERIS's vapor hydrogen peroxide (VHP) to the AeroClave system was achieved and an evaluation of the field data for this combination has been submitted to the FAA. A scaled up demonstration using a widebody (747, located at CAMI) airframe is underway as of the date of this document. Work in the laboratory (approaching 2,000 samples) indicates the presence of some materials compatibility issues, but it appears that these are manageable. The depth of the ACER materials compatibility study goes far beyond previous studies. This study will provide at least part of the answer to the question, could VHP be used safely in airliners? The modeling work encompasses a 18 first class, plus 198 economy seat widebody aircraft and models decontaminant flow and mixing efficiency with and without fans. Modeling work indicates that enhancements to VHP delivery methods are possible without increasing system cost.

The bottom line thus far: Very promising results have been obtained from the full-scale demonstration on a DC-9. ACER is currently conducting a scaled up trial with a 747 March 2007. Major progress has been achieved in supporting laboratory experiments and modeling.

9 Disease Transmission

ACER's newest project aims to synthesize work being conducted in many other ACER projects to define the role of the airliner cabin environment in disease transmission and hence any needed responses. This work has just commenced as of the date of this document.

The bottom line thus far: A new project that is just commencing.

10 Industry Partners

ACER's industry partnership continues to grow. Current members that have costshared are:

- AeroClave
- Airline Pilots Association
- Aldec
- Altera Inc.
- The Boeing Company
- COPE International-USA
- Delta Air Lines
- Donaldson Company Inc.
- Fluent Inc.
- GE Aviation
- Goodrich Sensor Systems
- Hamilton Sundstrand/UTRC
- Honeywell
- Int. Cent. Indoor Environ.
- Keddeg Company
- Microchip Technology Inc.
- nzymSys Inc.
- Pall Aeropower Corporation
- Spitfire Aviation Partners
- STERIS Corporation
- Strategix LLC
- TSI Inc.
- Xilinx Inc.

ACER has also added LG Electronics and Samsung as International Affiliate Partners and The MITRE Corporation as a contributing partner. ACER welcomes new industry partners.

11 More Information

For more information, please contact the ACER Executive Director William Gale at galewil@auburn.edu and/or visit the ACER web site at acer-coe.org.

12 Acknowledgements and Disclaimer

ACER is funded by the FAA's Office of Aerospace Medicine, under a series of cooperative agreements between the FAA and the member universities. Although the FAA has sponsored this project, it neither endorses nor rejects the findings of this research. The presentation of this information is in the interest of invoking technical community comment on the results and conclusions of the research.