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U.S., Canadian and European Aviation Authorities Coordinate Cabin-safety Research

The Cabin Safety Research Program is described as a totally integrated plan that allows three separate aviation-safety authorities to get the most from their cabin-safety research budgets.

Robert L. Koenig
Aviation Writer

For decades, aviation authorities in the United States, Canada and western Europe have conducted cabin-safety research with no formal coordination, other than occasional joint research projects.

Although much of the aviation agencies' research has been excellent, the lack of international coordination has at times resulted in duplication of research efforts and incomplete coverage of cabin-safety issues.

To enhance the effectiveness and timeliness of their cabin-safety research, the U.S. Federal Aviation Administration (FAA), Transport Canada Aviation (TCA) and Europe's Joint Aviation Authorities (JAA) have proposed the Cabin Safety Research Program (CSRP). The Japanese civil aviation authority has also been invited to participate.

The CSRP — described in a report, *Proposed Cabin Safety Research Program (Transport Category Airplanes)*, issued jointly by the three aviation authorities — is designed as a "totally integrated program" of coordinated research to help get the most out of tight research budgets.

The CSRP was presented in November 1995 at the International Conference on Cabin Safety Research, which included program discussion and speakers who described individual projects.[1]

Although the aviation-safety authorities have cooperated on rule making in the past, this initiative represents their first systematic cooperation in cabin-safety research. "The goal of the [CSRP] is to provide a mechanism for the coordination of pertinent activities and, as appropriate, the conduct of cooperative, joint and complementary programs to the benefit of the three authorities," the report said.

That mechanism is an international framework designed to allow experts at the aviation authorities to identify, prioritize and coordinate needed research in a systematic manner. And, as the research progresses, the research plan will be refined. The program includes some studies already in progress and a few that have been completed.

In the new program, cabin-safety research will focus on protecting cabin occupants against acute events, rather than longer range concerns, such as cabin air quality, that could be addressed by changes in the cabin environment.

"The primary focus of cabin safety is on postcrash survivability ... ," the report asserts. The aviation authorities define that concept to include impact protection where evacuation is not critical, as well as factors that affect the speed or safety of evacuations.

"Principal elements include crash dynamics, fire safety, evacuation, ditching, in-flight medical emergencies and the effects in the cabin from turbulence and decompression," the report said. "These subjects include in-flight as well as postcrash considerations and cover the spectrum of areas included in this plan." The project scope also includes "general design practice (e.g., no sharp edges or tripping hazards)."

Since the early days of aviation, cabin-safety research has concentrated on two areas:

- Finding ways to accelerate evacuation from an aircraft. That includes research into exit sizes and access provisions, the design and performance of escape slides and the effects of features in the cabin's interior on evacuation; and,

- Developing ways to prolong the time available for evacuations. That includes research into the flammability of cabin materials, the effectiveness of fire-protection systems and, in recent years, research into impact protection and human tolerance of crash conditions.

Although similar research has been done involving other transportation modes, the report said, "the airplane environment is unique in its constraints. The fragile economic posture of air transport dictates that some compromise in absolute safety is necessary in order that commercial air travel remain viable ... ."

For example, installers of fire-protection systems for buildings do not have to be concerned with weight factors; emergency exits designed for buses do not have to allow for maintaining cabin pressure. "For this reason, aircraft-cabin safety has essentially no direct parallel, and it is necessary to conduct dedicated research," the report said.

Until recently, most cabin research was highly focused and conducted independently of other nations' research efforts. In the United States, FAA evacuation research is conducted at the FAA Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma; fire-safety research is conducted at the FAA Technical Center (TC), at Atlantic City International Airport, in New Jersey; and research into crash dynamics is conducted at both FAA facilities, with CAMI concentrating on human tolerance and seating systems and the TC focusing on airframe structural performance.

In the 1950s and early 1960s, most cabin-safety research focused on the speed of evacuations rather than on extending the time available for escape. That research resulted in improved regulations for exit sizes, access to exits and the performance of escape slides.

In the late 1960s and early 1970s, much research focused on establishing safety standards for wide-body aircraft, including the development of Type A exits and reconfigurations of the cabin interior. [Type A exits are floor-level exits at least 42 inches (106.7 centimeters) wide by 72 inches (182.9 centimeters) high, with corner radii no more than one-sixth the width of the exit.] By the late 1970s and the 1980s research focus shifted to prolonging the time available for evacuations. Extensive fire testing led to standards for cabin materials, and numerous regulations governing fire-protection systems and materials flammability.

In recent years, more research concentrated on impact protection. Researchers evaluated the structural capability of the airframe; developed test standards for occupants and a restraint system that reflected those standards; and applied known parameters of human tolerance (some from automobile testing) to develop pass/fail criteria for impact-protection standards.

"While these research areas have been very productive ... they have largely been carried out independently of one another," the report said. "Up to now, there has been no formal vehicle to integrate cabin safety research so that the benefits are maximized and the available funds are spent most efficiently."

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The nucleus of the CSRP will be a comprehensive new benefit-and-risk analysis — based, in part, on a survey of past aircraft accidents and incidents.

The study will collect and store, in a special cabin-safety library, all available information relating to cabin safety in past incidents. One model for the study is the recently completed benefit analysis for cabin water spray.[2]

In performing the new benefit-and-risk analysis, experts will try to update past accident data by estimating and including the influence of safety improvements that have been made since the accident.

"The information gathered will be used to identify problem areas in cabin safety, determine the benefit (or dis-benefit) in safety improvements (likely benefit from R&D [research and development]) and determine the synergistic effects of a cabin safety improvement on overall cabin safety."

The study results will be used to develop a "probabilistic risk analysis." That risk analysis will aim to "provide more insight into potential safety benefits by attaching probability of occurrence to targeted events to balance the absolute safety benefit." This approach differs from traditional benefit analyses, which simply extrapolate benefits based on previous accident rates.

The benefit-and-risk analysis part of the CSRP will be updated continually with new accident and incident data. The goal is to use the approach "to tie together cabin-safety issues and assist in the setting of priorities by looking at the total cabin-safety picture," the report said.

A CSRP steering committee will establish priorities, direct and guide research and attend to major issues such as funding and joint research.

A separate technical group will be responsible for technical management of research, including identifying and prioritizing research projects, as well as overall planning, coordination and direction of such projects. The group will not be involved in day-to-day project management.

The technical group, which will hold regular meetings three times to five times a year, will brief the steering committee regularly on the progress and findings of research projects, as well as on other aspects of the research program.

The FAA, the TCA and the JAA will each contribute members to the technical group. Members will be selected to represent both research and regulatory elements of each aviation authority.

On occasion, experts from external research organizations or other government agencies will be invited to participate in the technical group's work. And the group will solicit advice on research needs and priorities from some industry and public groups, as well as aviation authorities' working groups and advisory committees. Those include the FAA Aviation Rulemaking Advisory Committee; the FAA Research, Engineering and Development Advisory Committee; the joint FAA/JAA/TCA International Cabin Safety Team; and the JAA Cabin Safety Study Group.

Listed below are current and planned research activities sponsored by one or more of the aviation authorities. Work being coordinated in a joint program is listed as a single project, but similar or parallel research projects by more than one authority are listed separately.

Benefit/Risk Data Base and Analysis

Project: Cabin-safety risk analysis
Performed by: FAA (TC)

The objective is to develop a risk-analysis model and computer program to compute the risk to airline passengers from cabin accidents and incidents, as well as the reduction of risk, and other benefits, from various cabin-safety improvements.

In developing the risk-analysis model, researchers will use safety analysis technology, historical data on aircraft accidents and incidents, the results of experiments and tests, predictions based on physical-science models and experts' opinions.

Initially, the model will be developed for a cabin water-spray fire-suppression system. But the model will be applied later to other safety issues to help compute the reduced probability of injury or death to passengers from improvements.

Among the cabin-safety issues that eventually will be addressed by the model are structural crashworthiness, occupant protection, passenger evacuation, fire safety, water survival, turbulence, decompression and medical emergencies.

Project: Risk-analysis data acquisition and development
Performed by: TCA

This project involves gathering data in support of the FAA's risk-analysis model. Those data will include the type and number of transport aircraft in service in North America and Europe; the capacity of each of those aircraft for passengers, flight crew and cabin crew, and the injury or fatality probability distribution for those persons; the number of departures for each aircraft type, as well as the departing and destination airports and operators; and detailed accident data from 1987–1993.

Project: Data-base analysis techniques
Performed by: JAA (United Kingdom Civil Aviation Authority [CAA])

Researchers will further develop the CAA's occurrence data base so that it can be analyzed more effectively. The current system will be expanded to integrate it with other data bases and to compare it with data bases in other industries.

Project: Analysis of survival criteria
Performed by: Direction Générale de l'Aviation Civile (DGAC)/Cherry and Associates Ltd.

An analysis of accident data will determine which factors, or combination of factors, affect the passengers' and crew's survival in accidents. The project will also make proposals to increase survivability.

Crash Dynamics

Project: Occupant crash protection
Performed by: JAA

This program will determine the scope of work for a larger research project aimed at improving occupant crash protection. The CAA, through the JAA, has initiated a major research program to examine design improvements to passenger aircraft that would increase accident survivability. The program will examine cabin-floor integrity, the safety of stowage bins and cabin equipment, improved occupant-restraint devices and other factors.

Project: Falcon 10 Crash Test
Performed by: DGAC/Dassault-Centre d'Essais Aéronautique de Toulouse (CEAT)

This study seeks to validate the structural crash-resistance computation model for small Joint Aviation Regulations (JARs)/U.S. Federal Aviation Regulations (FARs) Part 25 aircraft. Airframes with six instrumented test dummies undergo dynamic testing; the results will allow researchers to compare experimental results with predictions.

Project: Side-facing seat certification procedure
Performed by: DGAC

New dynamic testing standards for seats are not adapted to side-facing seats, which are found in many business jets. This project will review the certification procedure for side-facing seats.

Project: Requirements for side-facing seats
Performed by: JAA

Researchers will investigate biomechanical load limits for side-facing seats, with respect to JARs Part 23 and Part 25 dynamic seat-test requirements. The study will compare the current requirements and advisory material for side-facing seats with those for automobile crash tests. Dynamic seat tests will be carried out using current side-facing seats.

Project: Occupant restraint
Performed by: FAA (TC and CAMI)

This project focuses on the dynamic testing of aircraft seating systems, including an analysis of seat-pan deformations and energy-absorption characteristics of seat cushions.

Project: Child restraints in aircraft
Performed by: FAA (CAMI)

Researchers will assess the performance of child-restraint devices when used in aircraft seats. Several child-restraint devices will be tested using the crash pulse now required for newly certificated designs.

Project: Aircraft-specific child-restraint system
Performed by: TCA and FAA (CAMI)

Automobile seat restraints for children have not been tested in aircraft-crash conditions, and some car child-restraint systems do not fit into aircraft seats. This project will develop and test a prototype child-restraint device for aircraft use.

Project: Consolidation of crashworthiness information
Performed by: FAA (CAMI)

Researchers will create a single, computerized, public data source on the performance and design of various seats and crash-protection systems. The data will be available both to the FAA and to industry.

Cabin Furnishings

Project: Cabin interior integrity
Performed by: FAA (TC and CAMI)

Researchers will develop methods for improving the integrity of interior cabin furnishings when they are exposed to dynamic loads, so furnishings do not block the path of crash survivors trying to exit the plane.

Project: Overhead-bin loading survey
Performed by: JAA (CAA)

This survey will assess the weight of baggage normally stored in overhead bins while aircraft are in flight.

Project: Cabin stowage compartment latch integrity
Performed by: TCA

Researchers will review the designs of latching systems for cabin stowage compartments on large aircraft, to determine the likelihood that the compartments will remain closed during emergency landings and evacuations.

Project: Aircraft interior safety
Performed by: FAA (TC)

This project will test fuselage-section cabin interiors to determine how overhead stowage bins respond to longitudinal decelerations and vertical drop tests, so stowage bin fracture loads and modes of fracture can be ascertained.

Human Performance

Project: Impact injuries to lower body
Performed by: FAA (CAMI) and JAA (CAA)

The goal of this project is to develop injury-risk measurement technology for the pelvises and legs of aircraft passengers. Pelvis and leg injuries are of special concern because they hinder survivors from escaping postcrash cabin fires.

Project: Improved anthropomorphic test dummies
Performed by: FAA (CAMI)

The anthropomorphic test dummies now mandated by FAA crashworthiness regulations are outdated. This research will evaluate the suitability and advantages of new dummy technology, including the development of better designs and measurement capabilities.

Project: Development of analytical models
Performed by: FAA (TC)

KRASH is a computer program that analyzes the effects of accidents on aircraft structural components. This research will enhance the program's ability to predict how different types of aircraft and terrain will affect advanced energy-absorbing seat designs, seat-cushion performance, infant seat/restraint systems and head injury criteria.

Evacuation

Project: Comparison of aircraft cabin evacuations using slides with evacuations using platforms
Performed by: FAA (CAMI)

Researchers will quantify differences in human behavior during evacuations using slides compared with those using sill-height platforms. Results will provide a scientific basis for evaluating test plans submitted to show compliance with FAA evacuation regulations, and will provide a basis for designing other evacuation experiments.

Project: Revisions and improvements to the 90-second rule
Performed by: FAA (CAMI)

This project's goal is to devise a better test for determining how quickly specific aircraft can be evacuated. The test currently required by FAA regulations is expensive, poses risks to test subjects and may not represent true emergencies.

Project: Passenger behavior and performance under various cabin and exterior lighting conditions
Performed by: TCA

Research will develop data to help identify and assess the factors that influence the behavior and performance of passengers during slide evacuation under various lighting conditions, both in the cabin and outside the aircraft. This will help determine whether the present requirement of low-lighting conditions for the 90-second evacuation test is appropriate.

Project: Development of computerized evacuation models
Performed by: FAA (CAMI)

Researchers will develop and validate computer models and parameter data sets for evacuations of aircraft cabins. The models will make it safer and less expensive for aviation regulatory agencies and industry researchers to analyze issues related to emergency evacuations. Three evacuation models now exist, but their parameter data sets are insufficient and have not yet been properly validated.

Project: Computer modeling of evacuations
Performed by: JAA (CAA)

This project aims to provide a valid computer-based mathematical model that will help resolve questions relating to the layout of seating and emergency exits in aircraft cabins. The model, called Exodus, will help show the "complex interactions of a real emergency evacuation."

Project: Development of an emergency evacuation simulation model
Performed by: TCA

Like the similar U.S. and European research, this Canadian project seeks to develop a computer-based model capable of simulating emergency evacuations. In addition to modeling the cabin layout, researchers will incorporate a wide range of occupant variables. Researchers can use the model for evacuation simulations, reconstruction of an aircraft accident and assessments of the influence of various hazard scenarios on aircraft evacuations.

Project: Quantifying the influence of anthropometry on evacuation performance
Performed by: FAA (CAMI)

Researchers will quantify the influence of age, gender, weight and height on evacuation performance. Such information is needed in designing experiments, evaluating test plans for evacuation demonstrations and considering changes in regulations.

Project: Duty stations of flight attendants for optimal evacuations through Type III overwing exits
Performed by: FAA (CAMI)

This project's goal is to find the optimal location for flight attendants to minimize evacuation time using Type III overwing exits. [A Type III exit is at least 20 inches (51 centimeters) wide by 36 inches (91 centimeters) high, with corner radii no greater than one-third the exit width.] This is particularly important for aircraft that do not have exits aft of overwing exits.

Project: Analysis of competitive behavior experimental protocols
Performed by: FAA (CAMI) and JAA (CAA)

Researchers will try to find out how "competitive behavior protocols," such as financial incentives, affect evacuation experiments. They will also seek to determine whether Britain's Cranfield Institute protocol and CAMI's incentives have different effects on test subjects.

Project: Influence of flight attendant behavior on cabin evacuation
Performed by: FAA (TC and CAMI) and JAA (CAA)

Simulated evacuations in a Boeing 737 will be carried out to determine how the number, location and behavior of flight attendants influence cabin evacuations.

Project: Improving passenger education
Performed by: FAA (CAMI)

Do the current preflight briefings by cabin crew adequately prepare passengers for emergencies? Researchers will review safety briefings to determine how to help passengers better retain and use the information.

Project: Passenger evacuation
Performed by: FAA (TC and CAMI)

To reduce the time it takes passengers to evacuate aircraft during postcrash fires, researchers will study the behavior of passengers and attendants — as well as the influence of aircraft configurations — on the speed of trial evacuations. A computer model also will be developed and correlated with evacuation tests, so that evacuation trials will be needed less often.

Project: Improved evacuation research facility
Performed by: FAA (CAMI)

Current test facilities are of limited use because they are located outdoors and rely too much on outmoded aircraft cabins. Researchers will design and build a better facility for aircraft-cabin evacuation research. In the proposed new facility, researchers could test both narrow- and wide-body aircraft, using as many as 200 subjects, in a flexible cabin with movable exits.

Project: Emergency evacuation from wide-body aircraft cabins
Performed by: FAA (CAMI)

The goal of this project is to document how emergency evacuations of narrow-body cabins differ from evacuations of wide-body cabins that have two aisles. A retired Boeing 747 will be used to conduct evacuation experiments, and the results will be compared to similar evacuation tests in narrow-body cabins.

Project: Improved evacuation slides
Performed by: FAA (CAMI)

As larger aircraft enter service, better evacuation slides will be needed. In this project, researchers will examine the defects of current slides and determine what improvements will be needed for a new generation of jumbo aircraft carrying between 700 passengers and 1,000 passengers.

Project: Ease of operation of Type III hatches
Performed by: JAA (CAA)

There have been complaints about delays in opening Type-III exit hatches during emergencies. Researchers will examine ways of making it easier to use such exits, possibly including retrofitting hatches with simple support mechanisms, such as hinges or spring-loaded devices, to make the hatches easier to open.

Project: Evacuation capacity of Type III exits
Performed by: JAA (DGAC)

Researchers will conduct evacuation trials to determine the evacuation capacity of Type III exits.

Project: Effect of abrupt changes in aisle direction on evacuation
Performed by: TCA

The development of telescoping seats that can be reconfigured to different widths in narrow-body aircraft has raised concerns about the resulting displacements, known as "jogs," in aisle direction. In this study, researchers will assess the effect of abrupt jogs on evacuations from single-aisle aircraft.

Project: Type III emergency exit handling
Performed by: DGAC/Airbus Industrie

This joint research project will evaluate the effect on evacuations of the following characteristics of Type III exits: the handle design, the overlapping width of the exit panel and the posted operating instructions.

Project: Additional evacuation research needs
Performed by: (To be determined)

If an urgent need develops for research into a particular cabin-safety issue, aviation-safety authorities should be prepared for swift action on such "reactive research." Potential areas of additional evacuation research include carrying mobility-impaired passengers; the possible delay in evacuation caused by passenger use of smoke hoods; and issues associated with other new safety systems.

Water Survival

Project: Water-survival factors in aircraft accidents
Performed by: FAA (CAMI)

Researchers will analyze differences between planned "water ditching" of aircraft and unplanned incidents in which the aircraft stops in water. This will include an analysis of all aircraft accidents during the past 30 years in which water survival was a factor, as well as a review of airline training programs and aircraft certification submissions concerning water survival.

Project: Review of required water-survival equipment
Performed by: FAA (CAMI)

Aircraft water-survival equipment has not advanced much since World War II; it still includes fishhooks, but global positioning system equipment, which would help locate crash survivors, is not required. In this project, researchers will modernize requirements for water-survival equipment carried on overwater flights.

In-flight Issues

Project: In-flight medical emergencies
Performed by: FAA (CAMI)

This survey of airlines' experiences with in-flight medical emergencies will provide insight into the most common types of medical emergencies and the adequacy of FAA-mandated medical kits. Researchers also will analyze the training given to cabin crew for handling medical emergencies.

Project: In-flight turbulence
Performed by: FAA (CAMI)

This project's goal is to recommend improvements in cabin operation and design to reduce injuries from turbulence, which continues to be a source of injuries and, occasionally, deaths in commercial aviation. Researchers will review how passengers were injured during in-flight turbulence.

Fire Safety

Project: Oxygen system safety
Performed by: FAA (TC)

Researchers will develop guidelines for improving aircraft oxygen systems to reduce fire hazards. Both bottled oxygen and solid-gas generator oxygen systems can malfunction in ways that result in hull loss. The project will identify the hazards of in-use oxygen systems and test improved oxygen installations.

Project: Onboard cabin water spray — new testing
Performed by: FAA (TC) and JAA (CAA)

This project will develop a water-spray system for fire protection, both in the cabin and elsewhere inside the aircraft. The goals are to improve water-spray system designs and to reduce their costs.

Project: Cabin water spray — cooperative program
Performed by: DGAC/Airbus Industrie

This study found that a cabin water-spray system was effective but needed improvement before being installed in aircraft. Other aviation authorities are examining the technical problems and costs related to installing cabin water-spray systems.

Project: Halon replacement
Performed by: FAA (TC) and JAA (CAA)

Researchers will determine which substitute fire-extinguishing agents are safe and effective enough to replace the current agents, Halon 1211 and Halon 1301. As part of the international effort to slow global warming, Halon production was terminated at the end of 1993.

Project: Seat components
Performed by: FAA (TC)

Seat accessories such as trays and passenger-service units can present a "significant fire load" if they are made of certain plastics. This research would develop a better fire-test method and criteria to evaluate seat-supporting structures and accessories.

Project: Regulatory support and accident investigation
Performed by: FAA (TC)

Aircraft fire-test laboratories in Europe, Canada and the United States will form an International Aircraft Material Fire Tests Working Group, which will improve and simplify fire-test methods. Projects include analyzing the permanence of seat fire-blocking layers, developing a fire-test standard for airline blankets and improving fire safety for accessible cargo compartments.

Project: Fuselage structural fire safety (burnthrough)
Performed by: FAA (TC) and JAA (CAA)

Using full-scale fire tests, this project will evaluate new techniques and materials for fuselage structures that may offer greater protection against ground fires. Researchers will conduct tests to determine if composite-skin aircraft would create greater hazards during a postcrash fire than do today's aluminum-skin aircraft, and if the pyrolysis product from composite skins creates hazardous smoke, toxic gases and combustible gases in the cabin. Researchers will develop a small-scale fire test to screen materials and designs before they are tested fully.

Project: Very large commercial transport fire safety
Performed by: FAA (TC)

The postcrash fire vulnerabilities of designs for future double-deck transport aircraft carrying between 500 passengers and 800 passengers, such as the very large commercial transport, have not yet been fully tested. This project will develop fire-safety requirements or guidelines for double-deck transports. The research will focus on the vulnerability of upper cabins to postcrash fires.

Project: Evaluation of materials' fire resistance
Performed by: DGAC/Aerospatiale

Researchers in this project studied the fire resistance of materials used in aircraft cabins, as well as the best approaches for handling those materials during postcrash fires.

Project: Mathematical modeling of aircraft fires
Performed by: JAA (CAA)

Computer processing improvements have helped speed the development of systems and software to enable more accurate modeling of aircraft cabin fires. This project aims to further refine such fire models to facilitate their usefulness as tools for both research and investigation.

Project: Long-range fire research
Performed by: FAA (TC)

With the goal of eventually eliminating fire as a cause of fatalities in aircraft accidents, FAA researchers are seeking to use advances in fire science and newly developed electronic, chemical and material technologies. Specific goals include developing a computer model to predict fire growth and propagation patterns; developing predictive means of assessing fire-safety matters; fireproofing cabin interiors; reducing the fire hazards from aircraft systems; and developing advanced fire-suppression agents.♦

Editorial note: This article was adapted from *Proposed Cabin Safety Research Program (Transport Category Airplanes)*, Report no. DOT/FAA/AM-95/14, October 1995, a joint publication by the U.S. Federal Aviation Administration, Washington, D.C.; Transport Canada Aviation, Ottawa; and Europe's Joint Aviation Authorities, Netherlands. The 60-page report includes an executive summary, a description of the Cabin Safety Research Program and summaries (which include objectives, background/need assessment, a description and identification of the performing organization) of all major research activities associated with the program.

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