EXECUTIVE SUMMARY

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The U.S. air transportation industry has an outstanding safety record. Yet passenger safety aboard U.S. airlines remains a continuing issue for the public, the Federal Aviation Administration (FAA), and the U.S. Congress. One concern is that aircraft be evacuated quickly and safely in an emergency.

FAA certification criteria and test methods are integral to evaluating the evacuation capabilities of new aircraft. In November 1991, the Subcommittee on Government Activities and Transportation of the House Committee on Government Operations requested that the Office of Technology Assessment (OTA) ". . . study the prospects for improving existing methods of evacuation testing in light of the need to balance realism against the safety of test participants. " [1] For this study, OTA examined regulatory, research, and technology issues related to passenger safety and evacuation testing.

Pursuant to Federal aviation regulations, aircraft manufacturers conduct full-scale demonstrations to show an airplane's basic evacuation capability and to evaluate crew training. FAA full-scale evacuation demonstration criteria include the following requirements:

- All passengers and crew must be evacuated from the aircraft to the ground within 90 seconds;
- The demonstration must be conducted during the dark of night or with the dark of night simulated, so that the airplane's emergency lighting system provides the only illumination of exit path and slides;
- specified mix of passengers "in normal health" must be used;
- Not more than 50 percent of the emergency exits may be used.

1 Barbara Boxer, chair, Subcommittee on Government Activities and Transportation, House Committee on Government Operations, letter to John Gibbons, director, Office of Technology Assessment, Nov. 19, 1991.

FINDINGS AND CONCLUSIONS

Benefits and Limitations of Evacuation Demonstrations

- Full-scale demonstrations are costly and expose participants to significant hazards. The cost of conducting a full-scale demonstration can exceed $1 million. On average, approximately 6 percent of participants are injured during full-scale tests. While most injuries have been minor, broken bones and paralysis have occurred. Fewer and less severe injuries than average occurred in the December 1992 MD-1 1 certification test in which slides were replaced with ramps.
- A full-scale demonstration simulates evacuation for only a narrow range of emergency conditions-an aborted takeoff at night involving no structural damage, cabin fire, or smoke, for a distinct subset of potential passengers (i. e., no children, persons with disabilities, or non-English speaking passengers).
- Demonstrations provide only a benchmark for consistent evaluation of various seating and exit configurations. The requirement to demonstrate complete evacuation within 90 seconds is not an adequate performance standard for measuring actual evacuation capabilities.
- Present evacuation certification rules do not encourage new technology development for extending the period of survivability in post-crash fires. The evacuation demonstration criteria are inflexible, regardless of the availability of technologies that could extend the period of survivability within the cabin.

Models and Simulations for Evacuation Certification

- At present, neither certification by full-scale demonstration nor by purely analytical certification methods is acceptable to all segments of the aviation community.
- The certification process will likely continue to rely on human test subjects in the foreseeable future. However, a combination of analysis and partial demonstrations or component tests can be developed to minimize the risk of injury and provide more comprehensive data on aircraft performance than full-scale demonstrations.
- Using aircraft manufacturers' analytical models, passenger egress rates through existing aircraft components are predictable. The results of industry analyses typically correlate well with observed rates through doors, aisles, slides, and other components under consistent test conditions.
- Human behavior in certification tests may be empirically modeled using data from prior demonstrations, but cannot yet be reliably "simulated." Estimates for average reaction times and egress rates are known for evacuation during controlled conditions. Because few reliable data exist on human behavior during accidents, the variations in human judgment and decisionmaking that might be expected for changing hazardous conditions cannot be predicted. These data cannot be obtained from current demonstration requirements, which do not address motivational effects or other behavioral factors that often exist in a real emergency.
- Recent computer simulation efforts may provide the technology base for a dynamic aircraft evacuation simulation capability, but the additional psychological data required for validating behavioral assumptions will be difficult to attain.

Data Issues

- FAA and industry could collect additional experimental data to support and validate evacuation models/simulations. Although FAA's present test fuselage is adequate for studying evacuation scenarios in single-aisle, narrow-body airliners, neither FAA nor any other regulatory agency has a facility that can be used to analyze egress from double-aisle, wide-body transports.
- Data on injuries related to aircraft evacuation testing are not readily available, nor are they classified by severity. Data from actual emergency evacuations are unevenly collected and analyzed. Neither FAA nor the National Transportation Safety Board collect information on precautionary evacuations.

Aircraft Evacuation Performance and Safety

- Survivability in commercial air transports is improving, largely through the introduction of highly fire-retardant materials and more crashworthy seats, restraints, and overhead bins. Though still a significant threat, fire has become less of a risk in survivable accidents. In the early 1980s, FAA attributed 40 percent of fatalities in survivable accidents, approximately 20 percent of total fatalities, to fire effects.[2] Between 1985 and 1991, approximately 10 percent of fatalities aboard U.S. airlines were related to fire.[3]
- Crew training and passenger motivation are as crucial to successful evacuations as the aircraft's design and equipment.

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2 Constantine P. Sarkos, manager, Fire Safety Branch, FM Technical Center, personal communication, June 3, 1993.

3 Office of Technology Assessment, based on FAA and National Transportation Safety Board data.

Flight attendant training, done in cabin mockups without passengers, may not provide crew members with sufficient skills for assessing flow control problems and motivating passengers to evacuate more efficiently. Simulation technologies may enhance training in passenger management and use of emergency equipment.

Passenger safety may be better improved by extending the period of survivability than by attempting to reduce the time required for evacuation. New technologies intended to delay deadly heat and toxicity levels after a crash would save more lives than feasible configuration changes intended to speed evacuation, according to a British analysis of aircraft accidents. Furthermore, demographic trends indicate that the average mobility of aircraft passengers will decrease in the future.