FLIGHT SAFETY FOUNDATION
CABIN CREW SAFETY
Vol. 31 No. 4 *For Everyone Concerned with the Safety of Flight* July–August 1996

Flexible Cabin Simulator Would Broaden Range of Cabin Evacuation Research

Passenger emergency evacuation research is limited by the inability to simulate many different cabin configurations, including those of aircraft in design stages. A flexible cabin-simulator facility, already designed, would allow researchers much greater control over variables.

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Aircraft cabin simulators are frequently used in experimental research on emergency evacuations of passenger aircraft. Most aircraft cabins currently used in studying emergency evacuations lack the flexibility to be configured in various cabin arrangements for the purpose of controlling research variables. A facility is needed that can simulate any aircraft cabin, from that of a small, commuter aircraft to that of a multiaisle, multideck jumbo transport, in a variety of experimental conditions.

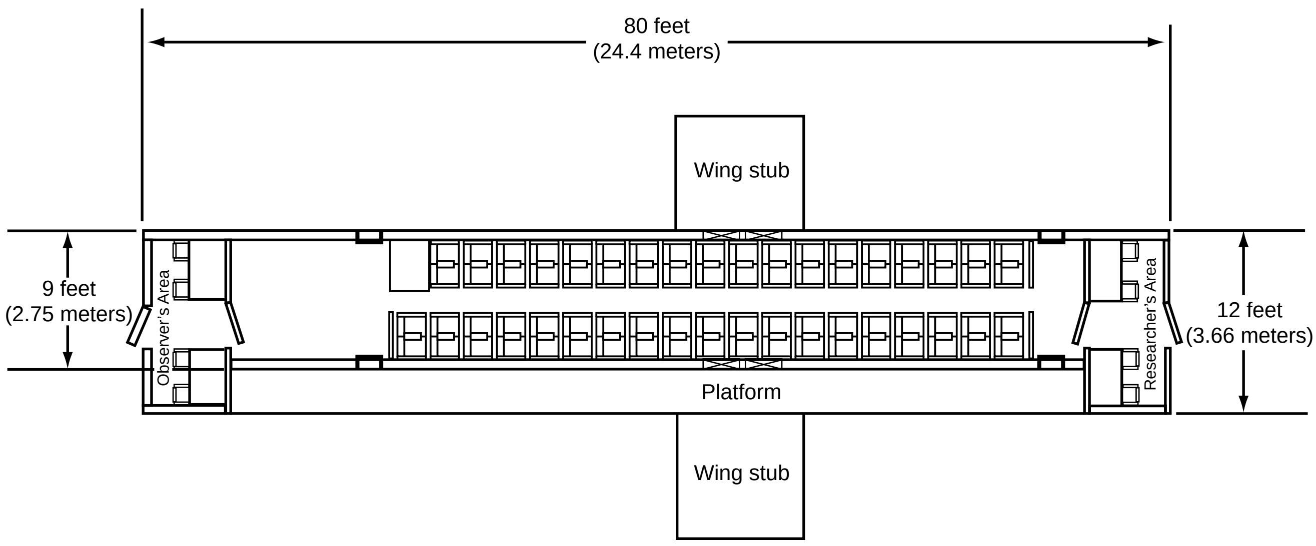
Figure 1 (page 2), the floor plan of a commuter aircraft's passenger cabin, and Figure 2 (page 3), the floor plan of the main deck of a triple-aisle, jumbo transport aircraft, illustrate two (of many) possible cabin environments for evacuation testing.

Research subjects are placed in a simulator configured to represent a typical airline passenger cabin and then asked to evacuate the cabin as quickly as possible. In subsequent trials, different aspects of cabin design, such as the width of aisles leading to exits or operational procedures, are varied. Interactions among experimental subjects, the amount of time they require to evacuate, their behavior while evacuating and the cabin design are studied, with the goal of determining which configuration allows the fastest, most efficient evacuation.

Current cabin simulators are either retired aircraft or special-purpose simulators that duplicate the cabin of a single, or a limited number of, aircraft. The inflexibility of such simulators limits the research that can be conducted with them. The location, size and design of exits cannot be changed. Cabin designs of future aircraft, such as those of multideck, multiaisle jumbo transports carrying 700 passengers to 1,000 passengers, cannot be simulated, nor can radically different aircraft designs be studied. These designs will present new questions about emergency evacuation. Finally, current simulators are not generally located adjacent to a pool, which precludes the study of evacuation from an aircraft into water.

Designing aircraft for emergency evacuations involves regulatory issues, but in some situations, decisions must be made for which there is little or no basis in scientific research. Frequently, the lack of research results from the lack of appropriate research facilities. For example:

- **Requiring a maximum of 60 feet (18.3 meters) between exits**. The relative safety of various spacings could not be shown experimentally because no facility exists for studies in which the distance between exits could be varied;



Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 1

- **Using exits of a different size or design from those specified in airworthiness regulations**. Determining the appropriate ratings for nonstandard exits and performing the tests that might justify their use is difficult; and,

- **Using evacuation slides with multideck aircraft**. Will there be slides from each deck, or will passengers have to return to a main deck before evacuating? If each deck has slides, will people exiting on a slide from one deck interfere with people exiting from an adjacent slide on a different deck?

The limitation of current evacuation research facilities to be reconfigured has hampered the collection of data and the development of validation exercises for computerized evacuation models. For the same reason, there has been only limited study of analytical techniques for addressing certification issues related to evacuation.

An aircraft cabin simulator is needed that can be reconfigured to study a broad range of evacuation issues. The most fundamental requirement of a flexible simulator is that it be able to simulate any type of passenger aircraft cabin, from that of a small, commuter aircraft to that of a jumbo transport, which can have as many as three aisles and three decks, with 3-5-5-3 seating. Within these constraints, any combination of passenger cabin width and length could be simulated. A crew of two to four technicians and investigators would be able to reconfigure the cabin in four weeks to six weeks.

Within the cabin, exits of any size or design could be located anywhere on either or both sides of the cabin. Interior fixtures and bulkheads of varying sizes and shapes could be installed anywhere within the cabin, and seat pitch (how close together the rows of seats are) would be adjustable.

Evacuation slides are an important part of the emergency escape system. The simulator would have to be able to use any current (or future) design of aircraft slide. This would require that the door-sill height be adjustable within the current range of aircraft door-sill heights. An open area at the end of each slide would be available so that research subjects using the slide could tumble at the end of the slide without hitting anything (e.g., a building wall).

Both cabin interior and cabin exterior illumination levels would be variable, to allow researchers to control for the influence of lighting levels on evacuation. It would be possible to introduce a nontoxic theatrical smoke into the cabin, which would obscure vision and, thus, simulate the visual impairment of smoke from an aircraft fire. After a smoke-filled cabin evacuation trial, the air in the simulated cabin could be exchanged quickly with clean air so that subsequent experimental evacuations could be conducted.

Early concepts of the flexible simulator envisioned that it would consist of a series of modules that could be assembled to represent the cabin configuration of interest. Practicality dictated that the system should be enclosed so that experiments could be scheduled and conducted at any time of day, without regard to weather.

Evacuation experiments require months of preparation and coordination among hundreds of people. Everything must be ready at the same time to conduct an experiment. Current research facilities that are located outdoors cannot be used to investigate issues related to cabin exterior illumination levels, or weather conditions may create unsafe conditions (thunderstorms). Use of a cabin-side pool for water-survival studies would also require an enclosed building. Thus, for researchers to have the ability to design, schedule and conduct experiments with full control of illumination and environmental conditions, the flexible simulator would have to be enclosed.

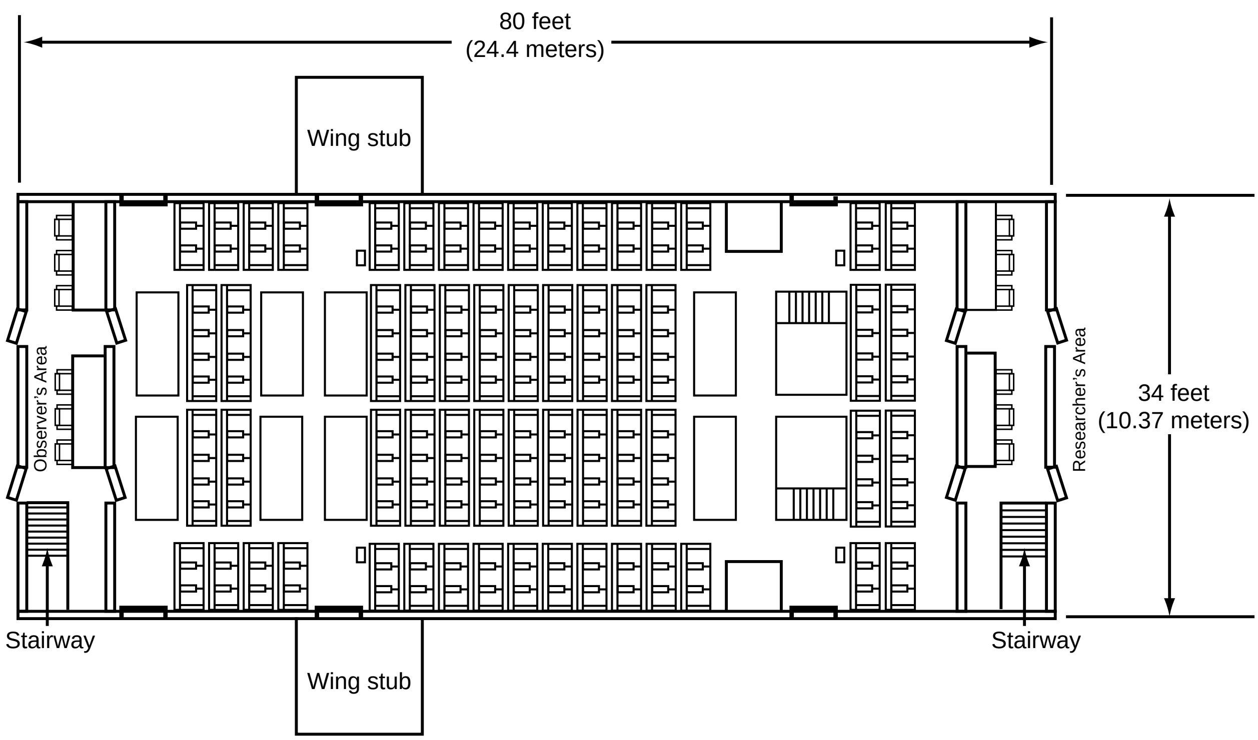
In addition to housing the simulator with an appropriately sized open area around it, into which research subjects could freely tumble when exiting a slide, the building would have to house a laboratory and a workshop and provide storage space for experimental equipment. This equipment would include the modules and fixtures required to configure the simulator.

The largest cabin for which the simulator could be configured is the triple-aisle, triple-deck transport. Experiments with this cabin configuration could require as many as 500 research subjects, all of whom would need to attend a safety briefing and sign consent forms to participate in the experiment. Basic information on each subject, such as height, weight, gender and age would have to be recorded. Subjects would have to be interviewed in a semi-private area about health problems that could make it unwise for them to participate in an experiment. In addition, when many people gather in a single location, requirements for bathroom facilities and parking for their automobiles must be considered.

Having a cabin-side pool to investigate evacuation into water would add further requirements. The pool would have to be wide enough for properly deployed aircraft slides and rafts, and long enough that a plane-load of people could be in the water without colliding with each other or with people exiting from the cabin. The pool would have to be deep enough and wide enough that subjects would not hit the sides or the bottom of the pool. To simulate evacuation from either or both sides of the cabin, either the pool or the simulator would have to be movable. In addition, research subjects participating in water survival studies need an area to change clothes and store personal belongings. Thus, locker room facilities for as many as 250 people of each gender would be needed.

Allen Consulting Inc. (ACI) was commissioned by the U.S. Federal Aviation Administration (FAA) to perform a concept design study for a flexible cabin-simulator facility.[1] The study provided guidance as to the feasibility and cost of a single-deck cabin simulator and a second simulator that could be configured as a multideck cabin, with as many as three aisles. The simulators would be housed in a building with a pool between them. Covers could be placed over the pool when

Jumbo Transport Main Deck Simulator Floor Plan



Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 2

evacuations from both sides of a cabin onto dry land were being studied. Both simulators would be on hydraulic positioning systems that could lift and tilt the simulators to any sill height and angle.

The proposed flexible simulator has a modular design. Simulated cabins are created by matching a number of modules representing short sections of a cabin. This module, in turn, is built from components representing such items as floors, ceiling, exits and walls. The modular design maximizes the flexibility of cabin arrangements and designs, making possible, for instance, a cabin configured to simulate that of a triple-deck, triple-aisle jumbo transport. It is envisioned that, for 15 years to 20 years after completion of the simulator, rapid fabrication and easy incorporation of new design features would be possible. Because only the module will have to be fabricated, it will be possible to study new design features at minimum expense. Future modules may represent different exit sizes or orientations, new types of door operations or radically different cabin designs.

The facility features approximately 36,000 square feet (3,348 square meters) of space for the simulator area, including a pool 45 feet (13.7 meters) wide, by 80 feet (24.4 meters) long, by 15 feet (4.6 meters) deep. The associated administrative area, including the subject briefing/lobby area, offices, locker rooms and equipment maintenance areas is 14,000 square feet (1,302 square meters).

As part of the ACI study for the FAA Civil Aeromedical Institute (CAMI), detailed cost estimates were prepared. The cost of the wide-body and narrow-body simulators was estimated to be US$5 million. The cost of the building required to house the simulators was estimated to be $11 million, exclusive of land. A later value engineering study reduced the estimated building cost to $7 million. Thus, the total facility was now estimated to cost $12 million. [CAMI has received initial approval for the project, but because of FAA budget reductions, funds have not been allocated.]♦

Editorial note: This article was adapted from “A Flexible Cabin Simulator” in the *Proceedings of the International Conference on Cabin Safety Research*, Report no. DOT/FAA/AR-95/120, March 1996.

Reference

1. *Design Concept Prepared for the FAA Flexible Aircraft Cabin Simulator*, FAA Contract no. DTFA-02-94-D94303. Aug. 1, 1995.

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Marcus received a bachelor of science degree in mechanical engineering from the University of Maryland. He performed graduate work in mechanical engineering at Michigan State University, where he participated in a U.S. Air Force–funded study that was ultimately used to model pilot ejection from a high-performance aircraft.

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