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Specialists Study Evacuation Challenges of Very Large Transport Aircraft

European researchers found that passengers could evacuate quickly from either the upper deck or the main deck of a cabin simulator. Nevertheless, potential difficulties — such as redirecting hundreds of passengers to use stairways and managing crowds outside the aircraft — require further study.

FSF Editorial Staff

Cabin crews of very large transport aircraft (VLTA) will face novel challenges in conducting evacuations — especially if passengers descend interior stairways instead of queuing at upper-deck doors — based on an 18-month project called the VLTA Emergency Requirements Research Evacuation Study (VERRES).

"VLTA designs currently being considered are capable of carrying 800-plus passengers with interiors consisting of two aisles and two full-length passenger decks," said the VERRES summary report, published by the Joint Aviation Authorities (JAA) for the European Commission. "VLTA is a generic [term] for future aircraft, and no specific aircraft was considered during the study. The Airbus A380 has been labeled a VLTA by some, but this study was much wider in nature, including potential future designs such as blended-wing[-body] style aircraft [having one deck or two decks with possibly four or more aisles]."

One method of managing/coordinating evacuation of a double-deck VLTA is to consider each deck as an independent cabin.

"This is the official hypothesis that has been selected for the emergency-evacuation certification demonstration (90-second test) of the Airbus A380," the report said. "In this condition, the stairs are not considered as an evacuation means and are not supposed to be used during the certification evacuation. But certification conditions are not real life, and in a real evacuation, any available means may be used to evacuate the aircraft."

Another method of managing/coordinating evacuation of a VLTA is to consider the two decks as one cabin.

"The main difference [between considering two decks as one cabin rather than as independent cabins] is that the use of stairs may be considered in nominal cases and not only in extreme cases," the report said. "Interaction between the decks should remain as limited as possible to keep the 'evacuation system' simple. Nevertheless, the use of stairs should be incorporated into the procedures and training." Decisions about these methods also could affect whether command and control of the evacuation process should be centralized (for example, with a "main purser" responsible for the upper deck and the main deck, including communication with the flight crew and one "deck purser" for each deck) or distributed (for example, with one deck purser responsible for each deck and one or both deck pursers responsible for communicating with the flight crew).

Teams of researchers from England, France and Germany recommended further study of several aspects of postaccident survivability, including practical problems that affect evacuation from double-deck cabins. Teams at Cranfield University and the University of Greenwich, both in England, and Sofréavia, a French civil aviation consulting and engineering company,

conducted experimental research as part of VERRES. Among the research tools were a computer model (i.e., software that simulates an evacuation) that has been validated extensively for VLTA research, and a double-deck large cabin simulator, which was used for eight experimental evacuations involving 336 individual participants.

In general, cabin crews will have to be prepared for inherent difficulties with situational awareness and communication because of the size, complexity and separation of VLTA interior spaces. Optimal coordination might require assigning cabin crewmembers to staircases combined with new types of safety procedures, safety briefings and safety devices.

After reviewing methods of evacuating large numbers of people from other transportation vehicles (including ferries) and from buildings, the researchers determined that the VLTA-evacuation situation is unique in its requirement for "a very fast evacuation resulting from the fire threat that is not found to the same level in other forms of transport, or indeed buildings."

One research challenge was visualizing what might occur if the behavior of passengers were to diverge significantly from planned VLTA evacuation technology and procedures.

"A feature of upper-deck exits is that the exit slides are much longer than those of more 'standard' exits," the report said. "For example, on the [Boeing 747], the upper-deck sill height is 7.8 meters [25.6 feet above the ground] and on the A380 it is set to be 8.1 meters [26.6 feet] above the ground. … While there is very little data concerning the use of upper-deck slides under certification-evacuation conditions, what data that is available suggests that … passenger exit-hesitation delays, while slightly longer, are similar to those of more standard exits."

The report said cabin crews will require training to overcome the following problems caused by the interior size/configuration of VLTAs, among others:

- Having an adequate mental picture of the whole cabin and providing passenger guidance to prevent spatial disorientation;
- Visually assessing obstruction of aisles, cross-aisles and situations at the opposite side of the cabin or in remote areas of the cabin;
- Conducting empty-cabin checks; and,
- Visually assessing the aircraft attitude, the usability of slides (including whether they extend to the ground), and ground conditions at the base of slides.

Moreover, emergency procedures may have to be extended to include details of marshalling passengers on the ground — for example, 800 passengers on one side of the aircraft while aircraft rescue and fire fighting (ARFF) operations are being conducted — and the ground handover of responsibility for passenger safety.

Staircases currently are built into some aircraft cabins for access to upper-deck seats, but how effectively VLTA staircases could be used by hundreds of passengers under emergency conditions remains an open question. Moreover, the Joint Aviation Requirements (JARs) do not address preventing injury by specification of aircraft-stair width, tread depth, riser height or handrails — or whether stairs must be staffed by cabin crew during an evacuation, the report said.

"Consideration must be given to the possibility that passengers, who are in the habit of using the stairs in normal operations, may decide to do so in an emergency," the report said. "Such passenger behavior has been observed in the VERRES experiments. This situation could rapidly become out of control with all the cabin crew busy at their own doors. … Large numbers of passengers behaving in an uncontrolled manner, perhaps in the presence of smoke or with the airframe in an uneven attitude, may inevitably lead to serious injuries and possible fatalities.

"Emergency-evacuation scenarios may develop where it is necessary or desirable to evacuate all or some passengers down the stairs and out the main-deck exits rather than out the upper-deck exits. While less likely, accident situations may also develop where it is necessary to move some passengers to the upper deck and out the upper exits."

Generally, the researchers found no basis for proposing changes to current wide-body-aircraft standards of seat pitch and seating density when applied to a VLTA. Nevertheless, experimental evacuations that represent highly motivated/competitive escape behavior were recommended to ensure that these standards do not cause problems when passengers encounter smoke in the cabin, which not only affects vision and breathing, but evacuees' ability to identify an escape route.

Based on review of standards in the JARs for sizes, numbers and types of aircraft exits, the report said, "Research should be conducted to enable the factors which influence evacuation performance through Type A exits[1] with slides to be better understood. These factors will include: passenger access routes to the exits, including widths of aisles and cross-aisles together with the aperture between bulkheads; visibility of the exits when passengers are seated; lighting levels in the vestibule area and at the exit [to] include the evaluation of new materials and intelligent systems to make the location and status of the exit more apparent to passengers; [and,] the minimum configuration for cabin crew assist space [i.e., an area required on one side or both sides of an exit that does not obstruct the width of the exit passageway but enables crewmembers to assist in the evacuation of passengers] should be reviewed. A revision to the regulations could then be considered which would prevent exits which are smaller than Type As being introduced onto VLTAs."

Cabin crewmembers who participated in focus groups questioned whether the number of exits and maximum distance between exits — under JARs 25.807, "Emergency Exits" — would be adequate for VLTAs. Procedures at the cross-aisles for

management of passengers and passenger flow control should be rigorously tested, the report said.

"In the event that testing indicates that congestion at cross-aisles is a problem, it may be necessary to reconsider the minimum requirement for 20 inches [51 centimeters] for cross-aisles or the positioning of cabin crew at these locations," the report said. "It may also be the case that if exits are easily visible to passengers, rather than being hidden by a bulkhead, this will increase the speed of their progress from their seats and down the aisle in an emergency. Research will be required to clarify this issue and to determine optimum aisle widths when passengers from main aisles and cross-aisles are required to merge together rapidly in an emergency."

Injuries during evacuations often occur on slides, such as when the airplane is in an unlevel attitude so that some slides do not reach the ground or when passengers prematurely use slides before full deployment.

"Many of the reported injuries … have occurred as a consequence of congestion at the bottom of the slides," the report said. "Marshalling passengers away from the bottom of the slides is not currently [a task assigned to] cabin crew. … It is a possibility that with VLTA, the minimum number of cabin crew will need to be considered, taking into account the potential need for cabin crew to be located at the base of the slides to marshal passengers away to safety."

Participating cabin crewmembers also discussed potential methods of lessening passengers' anticipated "anxiety and hesitation of using the [upper-deck] slide," such as developing fully enclosed tubes or slides with sides that would limit passengers' view from the top of the slide to the ground.

Researchers' analysis of video recordings of earlier aircraft-certification evacuations found that the absence of an adequate assist space also could slow evacuations, the report said.

"By increasing the size of the assist space and relocating the grab handle, it may be possible to design a situation in which the cabin crew can provide sufficient assistance to the passengers to ensure that there is continuous dual-lane slide use without any restriction caused by the presence of the cabin crew," the report said.

The cabin crewmembers said that factors considered in determining the size and composition of a VLTA cabin crew should include "the number of exits, possible redirection points, potential blockage points where aisles cross or combine, and the location and number of staircases." All VLTA cabin crewmembers should have the same level of emergency training and be interchangeable in their abilities to conduct crowd control, use passenger-communication systems and conduct evacuations from the upper deck and main deck, they said.

Cabin designers should consider separate public-address (PA) systems that enable communication with passengers in different areas or compartments for crowd-control purposes, and possibly introduce intercrew communication via wireless, hands-free headsets, the report said.

For insight into such issues, research teams compared findings from the computer simulations and the experimental evacuations with cabin crew interviews, analysis of group behavior and assessment of coordination requirements.

Computer simulation of aircraft evacuation is not accepted by European civil aviation authorities in lieu of evacuation demonstration. The advent of VLTA represents a new opportunity to refine methodology to eliminate the risk of human injury in evacuation demonstrations, the report said.

"The introduction of computer-based analysis techniques coupled with partial practical testing using people offer the potential of reducing all of these risks and costs while making the certification process arguably more rigorous," the report said.

A model was used to study the following VLTA scenarios: a precautionary evacuation in which all of the exits were available; a standard 90-second demonstration, in which only one side of the aircraft's exits were available; a variation of the precautionary evacuation in which all passengers used the main-deck exits (varying the control by cabin crew, main-staircase width and location of staircase); and sending some passengers from the lower deck to the upper deck for the evacuation.

Each time a simulation was conducted with the model, a different result was generated because the *simulated* passengers were programmed not to repeat the same sequence of actions. Each scenario was repeated 1,000 times; the simulations typically showed similar patterns of evacuation.

"It is apparent that the majority of passengers [simulated by the model] evacuate the aircraft in a very short period of time," the report said. "Further examination of the data reveals that, on average, a passenger wastes some 46 percent of … personal evacuation time in congestion. … We also note that on average, the upper deck finishes 2.1 seconds ahead of the lower deck [measurements excluded time that evacuees spent on the slide].

"In the specific [cabin] design investigated [with the model], it was shown that the two-lane staircase could not cope with the passenger flow generated by the two main-cabin aisles, resulting in a bottleneck at the head of the stairs and under-utilization of the main-deck exits," the report said. "Suggestions for improving the overall evacuation time under such conditions include widening the staircase or providing an additional staircase. If the staircase were widened, relocating the staircase to a more central location with access to additional lower-deck exits would also be required in order to reap the full benefits afforded by additional stair capacity."

The double-deck large cabin simulator was used to explore VLTA passenger flows in the following situations: Passengers were offered free choice between usable exits on both decks; passengers on the lower deck were required by cabin crew to move to the upper deck to the only usable exits; and passengers on the upper deck were required by cabin crew to move to the main deck to the only usable exits.

Passenger flow rates could not be determined, however, because the participating cabin crews conducted these experimental evacuations using commands/methods that had not been anticipated by the researchers.

During debriefings, some cabin crewmembers said that they had moved from their assigned assist spaces to the staircase because they believed that their cabin areas were clear of passengers and that crowd control was required at the stairs. Another factor was that the staircase had restricted the cabin crew's view of passengers, the report said.

"These trials support the view that for [cabin] crew to consistently make appropriate or optimal redirection-command decisions that include the possibility of using the stairs as part of the evacuation route, they must have sufficient situational awareness," the report said.

In summary, effective communication is expected to provide the best defense against any breakdown of coordination by a VLTA cabin crew during an evacuation. A complete communication loop (including efficient message-feedback for common situational awareness) and standardized VLTA emergency phraseology will be especially important, the report said.♦

[FSF editorial note: This article, except where specifically noted, is based on the *Joint Aviation Authorities [JAA] Very Large Transport Aircraft (VLTA) Emergency Requirements Research Evacuation Study (VERRES) — A Project Summary,* JAA Research Paper no. 2003/1, November 2003. The 109-page report contains tables.]

Note

1. European Joint Aviation Requirements 25.807, "Emergency Exits," defines a Type A exit as "a floor-level exit with a rectangular opening of not less than 42.000 inches (1.067 meter) wide by 72 inches (1.829 meter) high, with corner radii not greater than one-sixth of the width of the exit." A Type I exit is "a floor-level exit with a rectangular opening of not less than 24.0 inches (609.6 millimeters) wide by 48 inches (1.219 meter) high, with corner radii not greater than one-third of the width of the exit."

Cabin Crew Safety

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