Evacuation from the Upper Deck: Merely an Exit Problem?

(if a problem at all)

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Abstract

Evacuation from a VLTA is attracting increasing attention in the media and on conferences. One issue is whether we must necessarily put up with higher egress times and higher numbers of injuries during evacuations from the upper deck compared to evacuations from a conventional main deck. The paper analyzes factors that possibly account for differences in the evacuation process between upper and main deck. At a first glance, there might be an exit problem, as, for instance, passengers may be afraid of the height and hesitate to jump. At a second glance, however, there might also be a cabin problem, if, for example, passengers feel unprepared for the unfamiliar jump and hesitate to be the first to jump. At a third glance, we might also be confronted with a ground problem, for instance, if more passengers are injured and remain seated at the bottom of the slide, making those passengers standing in the exit hesitate to jump. Research is needed in order to insure that evacuations from the upper deck can be managed as safely as they are today from the main deck of conventional aircraft.

Introduction

The evacuation of Very Large Transport Aircraft has become a much debated issue. The discussions focus mostly on the new double-deck aircraft under construction, and in particular on evacuation from the upper deck. The upper deck door sill will, after all, be around 8 metres above the ground.

Why is this issue attracting increasing attention? As far as the general public, and in particular potential passengers are concerned, the attention paid to evacuation issues in media and conferences is natural: the new aircraft, bigger than all previous aircraft, stimulates the fantasy and brings up images of disasters. But the attention is understandable from a business perspective, too: there is intense competition on the market and airlines think twice before investing money in the new aircraft. This is all the more true in the present political and economic situation.

Aircraft manufacturers and certification authorities are negotiating about the certification procedure. Should a full scale demonstration test be required? In the case of the new aircraft under construction, this would imply evacuating 356 passengers from the main deck and 199 passengers from the upper deck. Or can we make do with a partial test, which would be composed of a demonstration test with a certain number of passengers, supplemented by a computer simulation of an evacuation of 555 passengers?

The main argument against a full scale demonstration test is the fact that this would almost certainly imply a larger number of (mostly minor) injuries. The more persons participate in a test, the more injuries are likely to occur. Is this a problem? Yes and no. In spite of the increased numbers of injuries, the probability of an individual being injured would remain unchanged compared to a partial evacuation. However, the greater *absolute* number of injuries may have a significant impact on the image of the aircraft, and may thus have to be avoided from a marketing point of view.

Another thought is certainly not trivial: More injuries may occur in the course of a test (and a real evacuation) due to specific features of the new aircraft. For instance, people might hesitate at the exit of the upper deck. But are there good reasons, are there *any* reasons to assume that the evacuation from an upper deck – the salient feature of the new aircraft – might lead to a higher egress time and / or a higher number of injuries than evacuation from a main deck? This is the question that the present paper will address.

At a first glance - an exit problem

What is the situation at the exit of an upper deck? The door sill is higher than in all other aircraft, and can be *much* higher - 11.5 metres - in certain situations, such as in the event of a broken gear when the body of the aircraft is in a slanted position. Passengers see and / or feel the unusual height. Some passengers may sit down rather than jump on the slide. Some passengers may hesitate to jump.

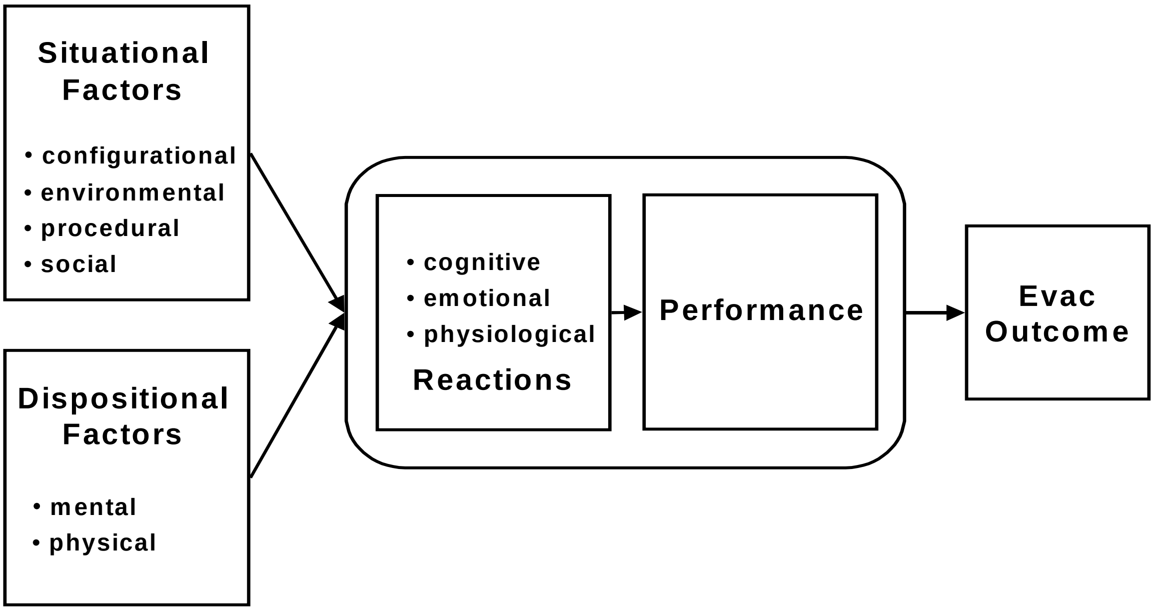

Figure 1: A general psychological model of evacuation performance

How will people behave in such a situation? The behavior at the exit is generally determined by two groups of factors (see Fig. 1): *Situational factors* include configurational factors (e.g., height), environmental factors (visibility), procedural factors (e.g., flight attendants´ instructions), and social factors (e.g., other passengers´ behavior). *Dispositional factors* include height-related physical attributes of passengers (e.g., age) and height-related mental attributes (e.g., fear of height).

Situational and dispositional factors determine the cognitive, emotional, and physiological reactions of passengers at the exit, and these reactions in turn determine their egress performance. A more detailed description of the model is provided in Jungermann (2000).

Based on this model, we have developed tools for assessing passengers´ dispositions and reactions, for analyzing behavior at the exit, in the slide, and on the ground, and for measuring times for each phase of the evacuation process. These tools were applied in pre-tests that were carried out on the so-called Megaliner, a double-deck mock-up with 42 seats and one exit (at Airbus Industries, in Hamburg). The aim of the first part of the project was merely to test and improve the tools: questionnaires, video recording, performance analysis, and time measurement technique. The findings of the pre-tests may be of some interest: (1) The hesitation time was higher on the upper deck than on the main deck. (2) Physical attributes such as age seemed to have a stronger effect on the performance on the upper deck than on the main deck. (3) Only a small percentage of test participants showed critical behaviors at the exit. The study is described in Jungermann & Göhlert (2000).

What conclusions can be drawn from this study? Or rather, what conclusions can *not* be drawn? First of all, that test participants or passengers show an increased exit hesitation time. In a newspaper article earlier this year, Ed Galea is referred to as having identified a small increase in exit hesitation time in early trials based on the A380 upper deck (*The Times*, 2001). The data from our study described above, however, though seemingly supportive for this statement, should *not* be taken as scientific evidence in that direction because the tests were run under varying conditions for developing methods and techniques. Actually, Galea (2001) has denied the statement and pointed out the fact that reliable data on hesitation times at exits of an upper deck are not yet available (see also *Air Safety Week*, 2001). In the stated article, Galea is further quoted as saying that people are intimidated by the height of the fall. This is a plausible assumption, and one which motivated our study. So far, however, our observations do not support it: only in very few cases was hesitation at the exit related to feelings of anxiety. When participants hesitated, they generally did so because they did not understand the instructions of the flight attendant at the exit or considered them to be inconsistent. What we observed was that participants (on both decks) focussed almost exclusively on the slide in front of them when they arrived at the exit. The effect is well-known and has been termed *cognitive tunnel vision* (Sheridan, 1981): under perceived danger, people narrow their field of attention to include only a limited number of central aspects. The effect seems to be reinforced by higher side walls at the top of the upper deck slide. Participants simply did not seem to see the height. We hypothesize that even if tests should demonstrate an increased exit hesitation time on the upper deck, this effect cannot not be attributed to subjects being intimidated by the height *when arriving at the exit*.

The main result of the pre-tests was that methods were developed which provide objective and useful data for examining evacuation performance. These methods can now be applied to investigate behavior systematically under different conditions. An additional result was the awareness that any analysis must not be limited to the exit but must also include other steps of the evacuation process.

At a second glance – (also) a cabin problem

What is the situation before passengers move to and arrive at the exit, i.e., in the cabin? A number of thoughts and emotions will be triggered by a call to evacuate. These influence the behavior in the cabin as well as at the exit. First of all, passengers on the upper deck *know* that they are on the upper deck. They know that this deck is very high, higher than what they are used to. Second, although passengers do not generally have first-hand experience of evacuations, they certainly have seen enough reports and movies to be able to imagine such a situation, or will remember personal experiences in similar situations - such as, for instance, standing on a 10 metres diving platform. Giving way to these imaginations can easily make you feel more anxious than necessary. While a diving platform overlooks sheer emptiness (apart from the water in the pool), the aircraft exit leads onto an escape slide. Other passengers might think of a swimming pool or playground slide. This, too, can cause inappropriate behavior. They might sit down at the top of the slide (as you would on a normal slide) instead of jumping. Finally, our interviews indicate that a number of passengers may feel uncomfortable in a diffuse way. The instructions given them at the exit *“jump into the slide, arms held in front!“* are slightly unusual. Most passengers have never in their lives performed such a jump. Many will be worried about doing it right - or ending up in the slide head first. In fact, „jumping on at top of slide“ was judged by 34% of the respondents as „difficult“ in a survey reported by Latman (2001), the second-highest percentage in that survey. And the question addressed evacuation from a main deck, not from an upper deck.

Being aware of the height, not having any experience of evacuations, and imagining what could happen and what to do can all have negative effects: Passengers may not want to be the first to jump and would rather let others go and jump first. Some may cause jams in the aisle when trying to let others pass, inducing panic among those who want to get out. Others may head for the lower deck and try to evacuate from there. (Stairways between the decks may not be needed for evacuation, but passengers may try to use them anyway. This is another feature of the new aircraft that needs to be considered when discussing *passenger flow control* (e.g., Madden, 2001).) Others might wait in their seats to let the people in the aisle go past, thereby blocking those in the window seats. Still others may decide to sit down at the top of the slide because that´s something they know how to do for sure. Finally, some passengers may hesitate when arriving at the exit - not because of the height they see but because of their insecurity how to perform the jump.

These assumptions are all plausible. Only empirical studies, however, can reveal whether these psychological factors are effective in the cabin and how they determine passengers´ evacuation performance. Helen Muir, well-known for her experimental work on passenger evacuation behavior in the cabin (e.g., Muir, 1996), will certainly address these issues with the new large cabin evacuation simulator at Cranfield University (Greene & Muir, 2001). But even without any empirical evidence, we can safely assume that speed and quality of performance will be improved if passengers are mentally prepared for the unfamiliar jump. Safety information is already being given in a number of aircraft with video clips, often on small screens closer to passenger seats than the conventional big movie screen far away. A briefing video could show passengers in slow motion, how they are expected to jump, accompanied by clear instructions. We have produced such a video, which could be shown as part of the general pre-flight instruction and again shortly before an emergency evacuation if there is time (Behrendt, 2000). An empirical study of its effects on passengers remains to be done.

At a third glance - (also) a ground problem

At the other end of the evacuation process, we have to consider the situation on ground, at the bottom of the slide. The slide from the upper deck is twice as long as the main deck slide. Logically, therefore, and under normal circumstances more passengers will be in the upper deck slide at a given time. As a result, jams at the bottom of a slide from the upper deck are likely to occur more often than at the bottom of a main deck slide. More passengers may be injured and unable to leave the slide or the immediate surrounding area; more passengers might remain standing at the bottom of the slide for any number of reasons: watching their partners slide or simply giving in to the relief of having made it.

But jams at the bottom of the slide can attract the attention of passengers at the exit and affect their behavior. Passengers about to jump might see what is going on at the end of the slide. In darkness, they may hear screaming from below. They will realize intuitively that they would be putting themselves, and those at the bottom of the slide, at risk were they to jump into the jam – and thus may hesitate.

Since a number of people often do get injured in evacuations, this description of the situation is probably realistic, even without the support of empirical studies. Not surprisingly, that, in the survey mentioned above, the highest percentage of the respondents (36%) judged „getting off at bottom“ as „difficult“ (Latman, 2001). Several conclusions can be drawn: (1) The mental preparation of passengers for the evacuation with the support of a briefing video can address this particular problem. (2) Specific instructions to leave the slide can be given by flight attendants at the exit. (3) Firefighters, if present at the moment of evacuation, can be instructed specifically to move people out of the way. (4) More generally, it „will be necessary to extend emergency procedures to the marshalling of those passengers already on the ground“ (Owen, Galea, Lawrence & Filippidis, 1998, p. 301). (5) Finally, since all these measures cannot solve the problem completely, a new design of the slide environment at the bottom should be considered which prevents the occurence of jams.

Final Conclusions

It is obvious that the evacuation issue requires a comprehensive analysis of all phases of the process (see Fig. 2). Potential causes for increased egress times and a higher probability of injury can be identified in the cabin (e.g., unpreparedness for jump), at the exit (e.g., intimidation by height), and on the ground (e.g., a jam of injured evacuees). We have to realize that egress time may be increased even if people are unable to hesitate for long at the exit because of the force of all those behind wanting to get out (as has been suggested). The technology is available to measure precisely the time that test individuals need for each step of the evacuation sequence: leaving their seats, in the aisle, at the exit, in the slide, on the ground. Furthermore, it is not only egress time and likelihood of injuries that have to be addressed. The behavior in the slide, anxiety and panic in the cabin, relief and concerns on ground are also important components that need to be taken into account. New challenges are posed not only by the existence of an upper deck but also by the sheer number of passengers in VLTA.

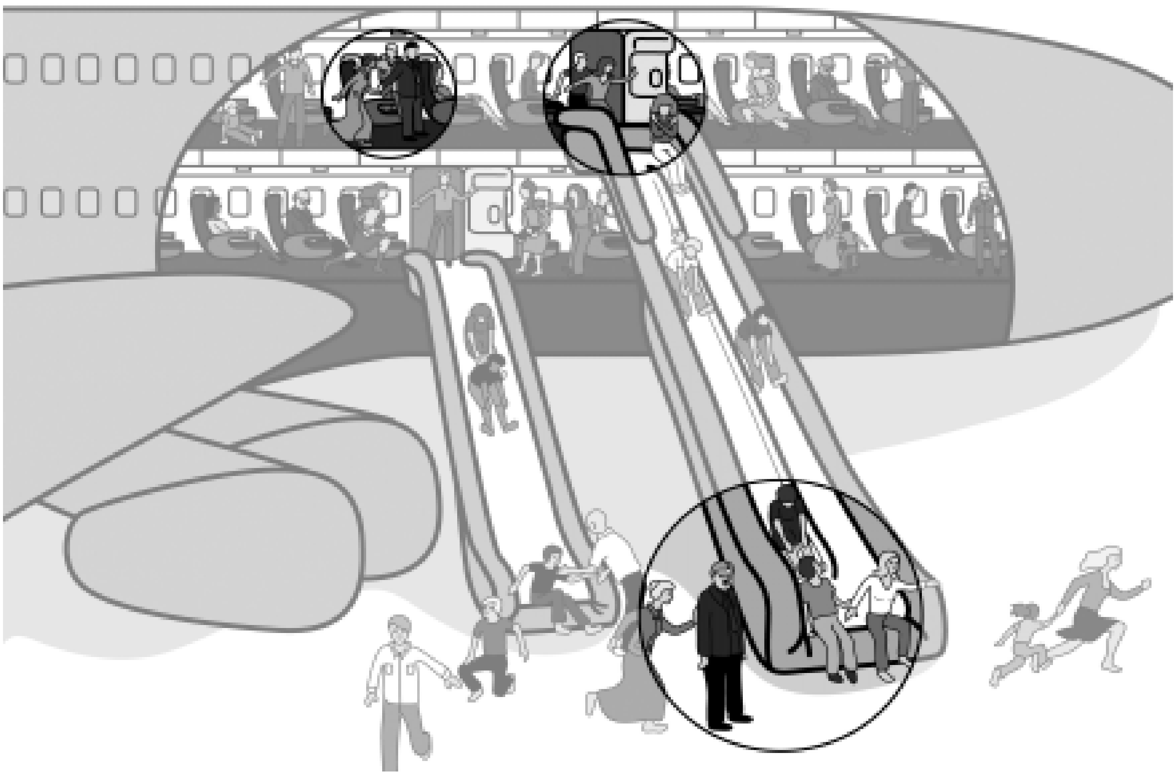

Figure 2: The three foci of a comprehensive evacuation analysis

Computer simulation can become an integral part of the analysis and perhaps of the certification procedure. However, they do not reduce the need for empirical studies. Simulation models such as the EXODUS model by Ed Galea are useful but not sufficient, as Galea (2000) himself has pointed out. Physical, physiological, and psychological processes can only be identified in empirical tests. These tests also quantify attributes and variables associated with the processes, and provide data for model validation.

While aircraft accident reports and aircraft certification reports and videos are important sources of data, these do not have the same quality as tests under carefully monitored and manipulated conditions. This is true in particular with respect to VLTA - for the obvious reason that the aircraft is not yet in existence and that real accidents and evacuations have not occured yet. Waiting for them to happen in order to analyze them is of course out of the question. At the same time, relying on findings from accidents and tests with conventional aircraft can be misleading. At the very least, we must find out what findings from conventional aircraft evacuations and tests can be generalized to VLTA and what findings cannot.

Is the evacuation from the upper deck a problem at all, or, more precisely, is it a bigger problem than the evacuation from a main deck today? Possibly not - but we just don´t know. Only empirical tests tell us. They can, and must, be conducted by manufacturers and airlines - and they should be requested by the certification authorities.

One final remark: Even if egress time and probability of injury during an evacuation from an upper deck should turn out *not* to be any greater than during a main deck evacuation, empirical studies are still useful. Tests provide insights and data that can help us diminish risks, improve the efficiency of evacuation management, and increase customers´ trust in the new aircraft.

Here, then, is the answer to the question that we put in the beginning: There is no reason to assume that evacuations from the upper deck pose higher risks than from the main deck. At the same time, there are a number of reasons for intensively studying the *human factors* in the cabin, at the exit, and on the ground. Results of such studies, run by aircraft producers or airlines, can help to improve evacuation technologies. They can´t make evacuation safe, but safer.

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