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16. Abstract At the request of AFS, the Cabin Safety Research Team performed an archival review of training events at our wide-body airplane cabin simulators with participants evacuating via an airplane evacuation slide. The purpose of this review was to evaluate if evacuation slide use technique differed as a function of participants use or deviation from the trained evacuation technique, and if the slide technique used was related to the frequency or likelihood of participant injury. This review found that most evacuations recorded during these training events used the trained techniques, and that it was not possible with this data to utilize inferential statistical techniques to determine if slide technique leads to higher rates of missed landing and/or injuries due to imbalance of observations between the groups using the trained techniques (n = 1202) and the groups deviating from the trained techniques (n = 72). A comparison of frequencies showed that the trained techniques had a lower rate of missed landings (12.23% - 13.79%) than other techniques (50% - 83.33%). Significantly more data would need to be collected to balance the observations in each group of participants deviating from the trained techniques to utilize inferential statistics with sufficient power to detect if there is a statistically significant effect not observed in the sample by chance.  This review also found that the trained technique is relatively safe, given the low number of missed landings and injuries observed over the number of training events and individual evacuations observed. Finally, given that the technique most observed in this archival review was the trained technique, and there were still missed landings and injuries using this technique, there must be some other underlying factor influencing these outcomes that would be better determined by a more controlled study of slide use techniques.			
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## Memorandum

Date: November 13, 2023

To: Tiffany LaTour, Project Sponsor, AFS-220, 623-238-0633

From: David Weed, Principal Investigator, AAM-632, 405-954-9218

Subject: Evaluation of Wide-Body Transport Category Airplane Evacuation Slide Training Technique and Injuries

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Tiffany,

At the request of AFS, the Cabin Safety Research Team performed an archival review of training events at our wide-body airplane cabin simulators with participants evacuating via an airplane evacuation slide. The purpose of this review was to evaluate if evacuation slide use technique differed as a function of participants use or deviation from the trained evacuation technique, and if the slide technique used was related to the frequency or likelihood of participant injury. This review found that most evacuations recorded during these training events used the trained techniques, and that it was not possible with this data to utilize inferential statistical techniques to determine if slide technique leads to higher rates of missed landing and/or injuries due to imbalance of observations between the groups using the trained techniques ( $n = 1202$ ) and the groups deviating from the trained techniques ( $n = 72$ ). A comparison of frequencies showed that the trained techniques had a lower rate of missed landings (12.23% - 13.79%) than other techniques (50% - 83.33%). Significantly more data would need to be collected to balance the observations in each group of participants deviating from the trained techniques to utilize inferential statistics with sufficient power to detect if there is a statistically significant effect not observed in the sample by chance.

This review also found that the trained technique is relatively safe, given the low number of missed landings and injuries observed over the number of training events and individual evacuations observed. Finally, given that the technique most observed in this archival review was the trained technique, and there were still missed landings and injuries using this technique, there must be some other underlying factor influencing these outcomes that would be better determined by a more controlled study of slide use techniques.

Additional information, including detailed descriptions of the techniques, the training events, methods of data collection and analysis, a breakdown of available data analysis and a longer description of results are available in the attached appendix.

Thank you,  
David Weed, Project PI.

Attachment – Appendix A - EoWTCAESTT&I Detailed Report.pdf

# Appendix A – Evaluation of Wide-Body Transport Category Airplane Evacuation Slide Training Technique and Injuries – Detailed Report

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# **Evaluation of Wide-Body Transport Category Airplane Evacuation Slide Training Technique and Injuries – Detailed Report**

## **Introduction**

This project was performed at the request of the Federal Aviation Administration's (FAA) Office of Flight Standards (FS). FAA's Civil Aerospace Medical Institute (CAMI) conducted a system assessment of the FAA controls in place to mitigate the risks associated with wide-body transport category airplane evacuation slide training techniques. This system assessment is part of an ongoing effort to provide improved guidance to make training and research activities involving airplane egress safer, with the goal of making airplane evacuations using slides safer. This project was developed to review archival videos recorded during training events utilizing evacuation slides at the FAA's CAMI 747 Aircraft Environment Research Facility (AERF), over a time where injuries were known to have occurred during training. The goal of this investigation was to see if correlations could be identified between the techniques utilized by the people during the training events and failures to dismount the evacuation slides, which would lead to higher risks of injury, and correlations between those same techniques and the injuries that occurred during the period under investigation.

## **Methods**

### **Facilities and Equipment**

The CAMI 747 AERF is an aircraft cabin simulator on the grounds of the Mike Monroney Aeronautical Center in Oklahoma City, OK. It was built using a Boeing 747-100 series that was acquired by CAMI in the 1990s and refurbished to suit the needs of a stationary wide-body aircraft cabin simulator, including retaining its original doors and evacuation slide attachment points for use in research and training. The evacuation slides used in this analysis were refurbished 747 slides inflated to and maintained at the manufacturer recommended slide pressure using a custom-built air-blower system designed with the capacity to support the deployment of eight 747 slides simultaneously.

## **Experimental Design and Assumptions**

Given the specific nature of the events used as the source of data for this archival review of video footage, there are fundamental assumptions that should be elucidated. First, the relative fitness level of the participants in the reviewed events can be considered above average, given that the participants were largely comprised of active military personnel or cabin crew trainers. Secondly, given that the participants were involved in a specific training event, they cannot be considered naïve for the purposes of generalization to the flying public. Finally, given the nature of the event and training, this review assumes that deviations from the training (improper slide technique) may lead to poor performance or failure to properly dismount during the evacuation and increase the risk of injury.

## **Descriptions**

Mount technique: for the purpose of the training and this report, two different slide-mounting techniques were trained as usable: jump-and-slide or sit-and-slide. Jump-and-slide was instructed as stepping or jumping out the door of the aircraft to land on the slide with the buttocks, rather than the feet. Sit-and-slide was instructed as sitting on the slide at the doorsill and pushing oneself onto the slide. Improper mounting technique was not encountered during any training events but would have been identified as exiting the aircraft in a manner not trained, with an example given of a participant jumping out of the aircraft and landing on the slide with their feet or using the slide in a prone, rather than supine position.

Slide technique: for the purpose of the training and this report, proper slide technique was defined as the user exiting the aircraft using the evacuation slide in a supine position with their legs straight and slightly elevated off the slide, with arms out to their sides to assist with stability. This technique was decided as the proper one based on historical impressions and discussions with high-volume airplane slide users, as it prepares the participant for a successful dismount at speed. Improper slide technique was defined as the participants using the slide with their arms or legs crossed during the slide.

Landing technique: for the purpose of the training and this report, successful (hit) landing was defined as the participant, upon reaching the end of the slide, cleanly dismounting the slide by planting their feet on the padding at the end of the slide and using their momentum to run/jog/walk away from the slide. Missed landing occurred when a participant failed to attain their feet and landed with any other body part on the padding (slip/trip/fall) at the end of the slide.

Military Egress Training: Military Egress Training (MET) Events are hosted by the FAA's Cabin Safety Research Team (CSRT) at CAMI. These are quarterly events for active-duty aircrew which include both the historical training procedure detailed in the Procedure section of this document, and a discussion of evacuation and post-crash safety equipment available on the aircraft the aircrew will be serving aboard. These events had between two and four evacuations, depending on group preference, at least one which included a cabin filled with theatrical smoke.

Cabin Safety Research Workshop: The Cabin Safety Research Workshops (CSRW) are research sharing workshops hosted by the CSRT up to three times a year. The target audience for these workshops are cabin crew, cabin crew trainers, engineers in cabin safety, and others academically interested in airplane cabin safety. The CSRW is a mixture of FAA research presentations; small group discussions with participants and Aviation Safety Inspectors; and hands-on, small group activities, including an egress activity at the AERF. The AERF egress activity includes a more in-depth historic discussion of the development of airplane egress systems as well as the standard historic training procedure. CSRW egress events include between two and four evacuations, at least one from a cabin filled with theatrical smoke.

## **Procedure**

### **Historic Training Procedure**

The CAMI AERF evacuation training event was a roughly 40-minute lecture given either in the classroom or in the AERF itself, which began with a history of evacuation assistance device research, development, and usage. This lecture included a safety briefing for using escape slides, with historical examples of potential effects of improper slide technique use, including

participant injuries. After the lecture and question portion, participants were directed to practice the evacuation route to simulate possible effects of disorientation or having to seek an exit other than the one that was closest, before the evacuations began. All classes experienced at least two and up to four evacuations, at least one of which included theatrical smoke. All evacuations were optional, and participants were instructed that they could opt out at any time.

For protection of the participants, padding was placed at the foot of the slide so that the participants would not be landing directly on the concrete around the AERF if they should have an improper slide dismount leading to a failed landing. First responders from the Oklahoma City Airport Rescue Fire Fighting service (ARFF) were on site for all evacuation events.

**Variables**

Eight variable participant states (Arms/Legs/Mount) were defined with two levels of outcomes (Landing) were identified for this analysis (Table 1). Slide technique was defined as position of arms and legs during the egress. This was a 2x2 definition with the participants having either arms crossed or arms out, and legs crossed or legs straight. Mount technique was defined as how the participant mounted the egress slide at the airplane door. This was a two-level variable with the participants using either the jump-and-slide or the sit-and-slide technique. Finally, landing was again two levels, defined as if the participant had a hit or missed landing.

Participant States			
<u>Arm Position</u>			
<u>Leg Position</u>	<u>Crossed</u>		<u>Out</u>
	<u>Crossed</u>	Arms Crossed/Legs Crossed	Arms Out/Legs Crossed
	<u>Straight</u>	Arms Crossed/Legs Straight	Arms Out/Legs Crossed (Trained)

**Table 1:** Participant states/variable levels

**Data Analysis**

Video analysis was conducted using government-supplied computers to review the archival videos using the Windows 10 built in media player, “Movies and TV”. Variable states and egress



outcome data points were recorded using Microsoft Excel 2016. All statistical analyses were conducted using Microsoft Excel 2016. Injury information was obtained from either video data inference or available accident/injury reports filed by the CSRT.

## **Results**

### **Training Events**

This archival review utilized the recordings of 16 events at the 747-AERF from 2014-2019. Of those events half (8) were MET events and half (8) were CSRW events. These 16 training events provided 46 evacuations (22 MET/24 CSRW) for this review. Of the eight CSRW evacuation events, all but two followed a pattern of three evacuations (clear air, smoke, “fun”) with the exceptions of Event-001, which had four evacuations, and Event-011, which only had two evacuations. Of the eight MET evacuation events, six followed the same three evacuation pattern while two, Event-003 and Event-016, only had two evacuations.

### **Facilitator**

Three different facilitators provided information to participants in the videos reviewed for this report. Facilitators were responsible for delivering the information to participants as well as regulating flow rate through the door onto the slide. All facilitators utilized the same safety information and slide technique briefing, while variations were introduced in the historical parts of the presentations both due to updated information and type of event (MET vs CSRW). Facilitator A had one event in 2014, Facilitator B oversaw nine events from 2014 to mid-2018, and Facilitator C oversaw six events in 2018 and 2019.

### **Participants**

Due to the nature of the review, each evacuation by a participant was recorded as its own evacuee data point, for a total of 1274 individual evacuees. This review determined that, of these evacuees 386 (30.30%) were female, while 888 (69.70%) were male. Finally, participant age was

not collected at the time of the training events and proved impossible to define in less than gross categories, which were not determined to be useful for the analysis.

### Landings and Injuries

Of the 1274 evacuees, the majority (1110/87.13%) had successful (hit) landings, while the remaining (161/12.64%) were missed landings. Of the missed landings, most (156/96.89%) did not produce an injury but could have contributed to injury during a normal or higher frequency evacuation due to blocking the end of the slide. Five (5/3.11%) of the missed landings produced an injury either confirmed with first responders entering the field of view or copies of accident reports in the more recent evacuations. The reported injuries were two rolled or sprained ankles and two broken legs requiring transportation and treatment.

Of the eight possible combinations of variables that the participants were able to control (arms/legs/mount), only six were found to be used during the events in this review. Of those six, five produced missed landings. Descriptions of these combinations and numbers of missed landings are found in Table 2. All injuries, reported and inferred, occurred with participants using the trained technique.

<b>Orientation</b>	<b>Arms</b>	<b>Legs</b>	<b>Mount</b>	<b>Observations</b>	<b>Missed</b>
<b>1</b>	Out	Straight	Jump	1144	140
<b>2</b>	Out	Straight	Sit	58	8
<b>3</b>	Out	Crossed	Jump	2	1
<b>4</b>	Out	Crossed	Sit	0	0
<b>5</b>	Crossed	Straight	Jump	63	52
<b>6</b>	Crossed	Straight	Sit	1	1
<b>7</b>	Crossed	Crossed	Jump	6	5
<b>8</b>	Crossed	Crossed	Sit	0	0

**Table 2:** Participant states and missed landing descriptive statistics.

It should be noted that, while all the injuries occurred using the trained technique, the rates of missed landings, when an injury would be likely to occur, do appear to differ based on the configuration of the participants arms and legs. Using the trained technique (Orientation 1) and sitting and sliding instead of jumping (Orientation 2) show very similar missed landing rates

(12.23% vs 13.79%) and using other orientations of arms and legs show much higher rates of missed landings (Orientation 3: 50%, Orientation 5: 82.53%, Orientation 83.33%).

### **Discussion/Limitations**

Overall, this archival review was a start of a larger effort to identify factors related to evacuation slide related injuries. The hypothesis was that slide technique, something that could be taught to professionals and potentially passed on to passengers, would be a major factor in missed landings and injuries seen in evacuation slide training. The results of this review show otherwise: most of the missed landings and all the injuries sustained were using the trained technique. Importantly, though, the rates of missed landings were higher using non-trained techniques.

It is possible that the event facilitator may have an impact on the likelihood of participant injury. Participants provided information by Facilitator C initially appeared to result in more injuries than the other facilitators. However, when looking more closely at the facilitators in context of missed landings, we see that when comparing facilitators B and C, they have similar rates of missed landings at 13.52% and 12.30%, respectively. Based on that and experiential data, the differences in injury rates are likely a function of reporting and records than actual injury rate, with injuries occurring under Facilitator C being better reported and fresher in the memory of the current research team than injuries under Facilitator B.

The limitations of this review are those inherent to all archival reviews utilizing opportunistic recorded data that was not collected in a rigorous way to fit the purpose of this specific review; the participants had no identification discernable from the existing videos and there was no other data recorded about the participants to identify any effects of variables which have been shown to be of concern in other areas of evacuation research such as height, weight, girth, and age. Finally, there was attrition in important data points such as reported versus inferred injuries.

### **Conclusions**

This report was envisioned as the first step in making airplane evacuations safer for trainers, and,

possibly, the flying public, by investigating if egress slide technique appeared to influence the likelihood of injuries. While this review found that missed landing rates were higher with the non-trained techniques, this review was unable to provide a statistically significant answer to that question. Future research with a more rigorous design would likely be required to conclusively determine if slide technique was a major factor in the likelihood of missed landings and injuries during evacuations. Given that most of the evacuations reviewed were using the trained technique, this data does not determine that there is no underlying factor influencing the likelihood of missed landings and injuries during evacuations using escape slides. In the absence of solid demographic and anthropometric data, as well as having no controls on the other conditions during these evacuations, it is difficult for this review to provide any definitive answers. Additional research with properly designed controls, or possibly even a broader collection of data recorded during future training events, may be able to determine those factors.

In conclusion, while this project cannot firmly determine if using the trained slide technique for egress reduces the risk of injury, it provides no evidence that justifies changing the current recommendations for future training events or recommended for depiction in passenger safety communication. It is still logically advisable, given how quickly a slide event occurs, to keep your arms out to make sure you do not roll over or jump a slide lane, and to keep your legs straight and ready to hit the ground running to help ensure that you can get off an evacuation slide quickly and safely when needed.