DOT/FAA/AM-05/2

Office of Aerospace Medicine
Washington, DC 20591

Caring for Precious Cargo, Part II: Behavioral Techniques for Emergency Aircraft Evacuations With Infants Through the Type III Overwing Exit

Cynthia L. Corbett

Civil Aerospace Medical Institute
Federal Aviation Administration
Oklahoma City, OK 73125

March 2005

Final Report

This document is available to the public through:

- The Defense Technical Information Center
  Ft. Belvior, VA. 22060
- The National Technical Information Service
  Springfield, Virginia 22161

U.S. Department
of Transportation

Federal Aviation
Administration

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-05/2		

4. Title and Subtitle	5. Report Date
Caring for Precious Cargo, Part II: Behavioral Techniques for Emergency Aircraft Evacuations With Infants Through the Type III Overwing Exit	March 2005
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Corbett CL	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
FAA Civil Aerospace Medical Institute P.O. Box 25082 Oklahoma City, OK 73125	11. Contract or Grant No.
12. Sponsoring Agency name and Address	13. Type of Report and Period Covered
Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

Work was accomplished under approved task AM-B-01-PRS-93.

16. Abstract

Introduction. Infant enplanements are estimated to be approximately 1% of all passenger enplanements. Yet recommended procedures for such *precious cargo* in emergencies are few. Previous research shows that passenger knowledge is a key factor in determining passenger responses in accidents, underscoring the need for detailed evacuation information and instructions for parents with infants/small children. The present study was conducted to identify a set of procedures to recommend to passengers with infants evacuating an airplane in an emergency, and consisted of evacuations using a Type III overwing exit, reported here, and a Type I floor-level exit with inflatable escape slide (see DOT/FAA/AM-1/18). The information obtained is intended for use in developing passenger education materials and pre-evacuation briefings. **Method**. Simulated emergency evacuations were conducted from the CAMI Aircraft Cabin Evacuation Facility. Six groups of 32 adults evacuated 5 times. Eight evacuees in each group carried dummies representative of infants 2 to 24 months old. On the first and last trials, no instructions were given as to how the dummies should be carried. On the intervening trials, infant carriers were instructed to carry the dummy horizontally or vertically, or to pass the dummy to another participant who had already exited. Theatrical smoke was introduced on the final trial. **Results**. MANOVA revealed main effects of carrying maneuver and dummy size on speed of egress. Carrying the infant dummy, horizontally or vertically, gave faster egress than passing the infant through the exit, especially with the smaller dummies. Overall, carriers rated carrying the dummy vertically as easiest, except for the 24-month dummy, which was considered to be slightly easier to pass to another person. For comfort and safety, infant carriers preferred the vertical orientation. On the first trial, egress through the Type III exit was significantly slower than egress through the Type I exit. In contrast, the egress times were essentially the same through both exit types on the final trial. **Conclusions**. Results confirm that passing an infant to another participant produces slower egress than carrying the infant. Results also suggest that the appropriate carrying orientation depends on the size of the infant. Infant carrier performance on the final trial demonstrates the beneficial effects of education and “hands on” experience in airplane evacuations.

17. Key Words	18. Distribution Statement
Infants/Children, Evacuations, Pre-Evacuation Briefings, Passenger Education	Document is available to the public through the Defense Technical Information Center, Ft. Belvior, VA 22060; and the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	24	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGMENTS

The author gives special thanks to Charles B. Chittum for the initial conception and preparation for this study. Without his focus on *Precious Cargo*, this study would not have been forthcoming.

A hearty *thank you* goes to Donell Pollard, retired, and Nancy Claussen, of the FAA Flight Standards Service, for both personal and professional support for this activity.

Thanks also to the Cabin Safety Research, Biodynamics Research, and Bioinformatics Imagery Teams who helped make this project a success.

Caring for Precious Cargo, Part II: Behavioral Techniques for Emergency Aircraft Evacuations With Infants Through the Type III Overwing Exit

Children younger than 2 years can fly on U.S.-registered carriers, seated on an adult's lap and without the purchase of a ticket (14 CFR 121); thus, neither the government nor the airlines can easily track the number of child passengers in this age group. The Federal Aviation Administration (FAA) submitted a report to Congress in May 1995 that estimated infant enplanements to be approximately 1% of all passenger enplanements. This estimate was based on a combination of air carrier surveys, industry experience, and a sampling of passengers. Applying this rate, the FAA has projected 80 million infant enplanements for the 10-year period 2000-2009 (Department of Transportation [DOT], 1998). Furthermore, the American Academy of Pediatrics (AAP) cites an estimated 4.6 million children younger than 2 years who fly on U.S. domestic airlines annually in their policy statement regarding the use of restraint devices (AAP, 2001). The importance of these "invisible" passengers in emergencies is generally unknown; similarly, recommended procedures for emergency management of such *precious cargo* are few.

When an emergency evacuation is required, passengers must engage in rapid and appropriate behaviors under stressful conditions. Parents may feel even more stress during an emergency than other passengers who do not have the responsibility of caring for a child. Since providing detailed information and specific instructions to people before and during an emergency has been shown to prompt action, reduce stress, and support the problem-solving process, it is clear that passenger knowledge is a key factor in determining how they will respond in an accident (Baddeley, 2001; Fritz & Marks, 1954; Johnson, 1997; Quarantelli, 1954; Weisaeth, 1986). Further, responses can be developed that will be automatically performed without conscious thought. Overt automatic behaviors (commonly referred to as *habits*), though they require a substantial amount of training (i.e., consistency and repetition) to develop, once learned, are difficult to change (Shiffrin & Schneider, 1977). Therefore, when appropriate responses are needed for emergency survival, they must be fully developed so that they are automatically activated at the appropriate time.

A review of accident/incident data collected by the Civil Aerospace Medical Institute (CAMI) identified 29 transport airplane accidents between 1970 and 1995 that required the evacuation of 67 infants (Chittum, 1998). Thirty-four percent of those children were injured: six infants received minor injuries, nine infants received serious injuries, and eight infants received fatal injuries. In addition, between January 1, 1988, and November 1, 1996, there were 519 precautionary emergency evacuations involving 42,835 transport airplane passengers and crew (Hynes, 1999, 2000). Based on the FAA estimates, these evacuations could have included as many as 1,500 infants; unfortunately, comprehensive infant passenger and injury statistics are not available.

In an accident investigation report for the May 10, 2001, accident of a Spanair McDonnell-Douglas MD-83 at Liverpool Airport, the Air Accident Investigation Branch (AAIB) of the United Kingdom (UK) Department for Transport recommended that the FAA, the Civil Aviation Authority (CAA) of the UK, and the European Joint Aviation Authorities (JAA) "should provide guidance as to the recommended best practice for the evacuation of infants and small children down escape slides with minimum delay" (AAIB, 2003). The reports states that there was some delay during the evacuation because of uncertainty as to the best method for evacuating small children or infants down the escape slides. Neither the passenger safety briefing nor the safety cards provided guidance for this type of evacuation. While the evacuation proved to be successful, there were only 45 passengers on the flight; the AAIB suggested that unacceptable delays might arise on an airplane with a full complement of passengers. (The airplane was configured with 170 passenger seats.)

The National Transportation Safety Board (NTSB) has recommended that the FAA "…[r]eview air carriers' procedures to ensure that for those situations in which crews anticipate an eventual evacuation, adequate guidance is given to both pilots and flight attendants on providing passengers with precautionary safety briefings" (NTSB, 2000). Nevertheless, a telephone survey of major airlines conducted for this study revealed that, in general, there are few recommended procedures for the emergency evacuation of infants.

Except for aircraft manufacturer demonstrations of an airplane's evacuation capability, in which infant dolls are included but not studied, evacuation research rarely includes infants and young children. Only one published study has specifically addressed the rescue of infants and children between the ages of 2 and 24 months (Garner & Blethrow, 1966). In that study, participants who were holding infant dolls in the emergency evacuation tests reported difficulty releasing their seatbelts and getting out of their seats.

To address the gaps in knowledge about evacuations with infants, preliminary demonstrations were conducted at CAMI to gather information on safe ways to evacuate small children from a crashed airplane (Chittum, 1998). Adults used a Type I floor-level exit fitted with an escape slide or a Type III overwing exit to perform simulated emergency evacuations while they carried dummies representative of six-month and two-year-old infants. Participants favored jumping onto the escape slide, while holding the dummy in an upright position with both arms around it, and cradling the dummy as they climbed through the overwing exit. Chittum noted a potential for injury to infants, observing that the head and limbs of the larger infant dummies often struck the side of the floor-level and overwing exit frames as they passed through. In addition, one participant almost dropped the infant dummy she was carrying as she attempted to sit down to board the evacuation slide.

While Chittum's (1998) observations and interviews with subjects participating in the evacuation demonstrations were useful, they did not adequately address the risk of injury to infants being carried by adults during emergency airplane evacuations. For example, infants may suffer mild to severe head trauma as a result of impact with the exit frame or being dropped during an airplane evacuation. Nor did Chittum consider the effects of egress with infants on the safe and efficient egress of other passengers.

The present study was conducted to identify a procedure or set of procedures to recommend to passengers with infants evacuating an airplane. The information obtained is intended for use in developing passenger education materials and pre-evacuation briefings that will inform passengers with infants and small children about the safest and most efficient methods for evacuating an airplane in an emergency. The study consisted of two parts, using two of the most common exit types installed on airplanes operated by airlines. The simulated evacuations were conducted in the CAMI Aircraft Cabin Evacuation Facility (ACEF) in Oklahoma City, OK. The first experiment of the study examined evacuations using a Type I exit with a single-lane evacuation slide. (See Corbett, 2001, for full description and detailed analyses.)

The second experiment, presented here, was expected to identify the most efficient, most comfortable, and safest techniques for an adult to carry an infant while evacuating an airplane through a Type III overwing exit. Participants carried infant dummies horizontally or vertically through the exit, or passed the dummy through the exit to another participant who had already exited the airplane simulator.

The age/size of the dummy was expected to affect the preferred carrying orientation/maneuver, as the head or limbs of the larger dummies could strike the frame of the exit opening as the carrier maneuvered through the exit. The heavier dummies were expected to be more difficult to carry and pass to someone outside the airplane, which would also slow evacuation. Egress with infants through the Type III overwing exit was expected to be significantly slower, overall, than egress through the Type I floor-level exit.

Since the use of theatrical smoke to obscure visual cues in previous research has been shown to produce differential effects on egress through floor-level and overwing exits (McLean, Higgins, Lyne & Vant, 1989; McLean, George, Funkhouser & Chittum, 1996), it was used on the final evacuation trial for each exit type. McLean et al. (1989) showed significant smoke-related egress slowing through the relatively small Type III exit opening. In contrast, McLean et al. (1996) failed to find an effect of smoke on egress through Type I floor-level exits with escape slides. These results were expected to be replicated. The effects of smoke on egress with infants through *both* exit types are evaluated and discussed here, as the effect of smoke was not addressed in Corbett (2001).

METHOD

Subjects

Six groups of 32 adult evacuees participated in the evacuation trials: four groups of U.S. Air Force and Navy personnel attending egress training at CAMI under a Memorandum of Agreement between the DOT and the Department of Defense (DOT, 1994a, 1994b), and two groups of airline industry representatives attending CAMI Cabin Safety Workshops. Thirty-two males and 16 females (eight participants from each group), ranging in age from 19 to 45 years (mean age = 31.9), were selected to carry anthropomorphic dummies on five evacuation trials. Thirty-nine of the infant carriers were parents.

Apparatus

A Boeing 720 Type III exit assembly, installed on the right side of the CAMI ACEF, was used for the simulated evacuations. The exit opening measured 20" wide and 38" high, with a step-up distance of 19" inside and a step-down distance of 27" outside the ACEF. To protect participants, tumbling mats were placed on the ground outside the simulator (see Figure 1). The interior was configured with six-abreast seating (e.g., Boeing 737), using two triple-seat assemblies, with a cabin interior aisle of 19 inches. The passageway leading from the main aisle to the exit was 20" wide with a 5" aft seat encroachment. Pitch for the remaining seats was set at 31 inches. An overhead lighting system was used during all trials, adjusted to minimum allowable emergency lighting level (0.05 foot-candle).

Materials

Eight dummies, representative of 2- to 24-month-old infants, were used. Table 1 summarizes the anthropometry for infants and children, newborn through 42 months, and Table 2 lists the measurements of the dummies used in this study.

A demographics survey (Appendix A) was used to screen all participants for potential infant carriers, based on the participants' stated physical ability to carry a 30-pound infant dummy, willingness to participate, and required gender mix for the sample. All group members were required to provide informed consent (Appendix B), in accordance with CAMI Institutional Review Board policy. Cabin Safety Workshop attendees were also required to obtain approval from their company supervisors to participate in the research project.

On the first and last trials for each group, no instructions were given as to how the dummies should be carried through the exit. The three intervening trials included instructions, printed on index cards, to carry the dummy either horizontally or vertically or to pass the dummy to a participant already outside the ACEF.

A post-test questionnaire, Emergency Aircraft Evacuations With Infants Survey (Appendix C), measured the infant carriers' perceived degree-of-ease and their preferred carrying orientation/maneuver with regard to comfort, safety, and recommended technique for parents.

Procedure

Demographic surveys were distributed to the groups as they arrived for class. The completed surveys were screened to identify potential infant carriers; eight were selected from each of the six groups.

Following the classroom training presentation, participants were briefed (Appendix D) as to the nature of the research, and the informed consent document was completed. Numbered vests were distributed to all participants, and dummies were given to the infant carriers. Participants were escorted to the ACEF, directed to sit in the seats that corresponded with their vest numbers, and given a safety briefing (Appendix E). Each group evacuated the simulator twice, without infant dummies, before the experiment began, in fulfillment of training requirements.

On the first experimental trial, infant carriers were instructed to hold the infant dummies on their laps, while seated, and to evacuate when the start buzzer sounded. A research team member removed the exit cover from outside the ACEF to preclude interference of exit-opening with the evacuation. Another team member acted as the "flight attendant," commanding the evacuation from behind the passenger queue, at the rear of the simulator. Participants reboarded, were seated, and infant carriers were given instruction cards that described how to carry the infant dummies for the next trial. Each infant carrier received a different specific instruction for each of the three instruction trials. Theatrical smoke was introduced in the cabin on the final trial, with no instruction as to carrying orientation. Following the evacuation trials, infant carriers completed the Emergency Aircraft Evacuations With Infants Survey.

Scoring

Speed-of-egress data. Speed-of-egress was operationally defined in two ways. First, *individual egress time* was calculated as the time (in seconds) it took for each evacuee to completely clear the exit opening after the previous evacuee was clear. This "total time" measure was comprised of any delay that might occur before the evacuee reached the exit after the previous evacuee had cleared the opening and the time it took to climb completely through the exit opening. Use of this measure was intended to allow for comparison of egress times between the exit types. Second, *exit negotiation time*, i.e., the time (in seconds) it took for each participant to climb through the exit opening (measured from the point in time at which the individual's or the dummy's body entered the exit opening until the individual's entire body had completely cleared the exit opening), was measured separately from individual egress time. The use of these two measurement techniques was based on previous research by McLean et al. (1996), using floor-level exits, and McLean, Corbett, Larcher, McDown, Palmerton, Porter, Shaffstall, and Odom (2002), using the Type III overwing exit. The passengers' ability to maneuver through the exit opening was the greater determinant of evacuation performance with the relatively small Type III overwing exit, with its bottom sill 19" above the floor. In contrast, passenger hesitation in using the escape slide predominated when using a floor-level exit, since movement through the exit opening itself was not restricted by exit size or orientation. Additionally, smaller exit openings and a smoke-filled environment have been shown to produce significant evacuation delays at overwing exits, especially when one's "personal ergonomic space" requirement is enlarged (McLean et al., 1989), as might be the case when an individual evacuates through the relatively small Type III overwing exit while carrying an infant.

Degree-of-ease data. Degree-of-ease was measured on a continuous scale labeled *Very Difficult* on the left and *Very Easy* on the right (see Appendix C). Infant carriers were instructed to mark an "X" at the point on the 6" line that corresponded with their perceived difficulty of each carrying orientation/maneuver (i.e., horizontal, vertical, pass). The distance from the *Very Difficult* end was measured in increments of eighths of an inch, with the higher score representing a higher degree of ease. This technique, where only the end points were anchored, provided participants with more flexibility in their responses (Bordens & Abbot, 1996).

RESULTS

All data screening and statistical analyses were performed using SPSS® version 12.0. Prior to analysis, the egress time and questionnaire data were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. Normality of sampling distributions, homogeneity of variance, and linearity were acceptable.

The speed-of-egress data were analyzed with a 3 x 4 (Carrying Orientation/Maneuver x Dummy Size) multivariate analysis of variance, using a general linear model (GLM), with carrying orientation as a repeated measure. The main effects reached statistical significance, with no interaction effects: Carrying Maneuver, $F(2, 88) = 34.04$, $p < .001$; Dummy Size, $F(3,44) = 3.62$, $p = .02$. The main effects accounted for 64% of the variance ($\eta^2 = .44$ and .20, respectively; see Table 3). Carrying the infant dummy through the exit, either horizontally or vertically, gave significantly faster egress than passing the infant through the exit to another person, especially with the smaller dummies (see Figure 2).

Degree-of-ease data were analyzed in the same manner as speed-of-egress data. Multivariate analysis of variance confirmed a significant main effect of Carrying Orientation/ Maneuver, $F(2, 88) = 9.52$, $p < .001$, but not Dummy Size (see Table 4). Overall, participants rated carrying the infant dummy vertically as easiest, with the exception of the 24-month dummy, which was considered to be (slightly) easier to pass out the exit to another person (see Figure 3).

Infant carriers chose the vertical carrying maneuver significantly more often than the horizontal carrying or passing maneuver for the carrying orientation/maneuver that they considered to be the most comfortable, the safest for the infant, and the one they would recommend to parents (see Table 5). Neither the participant's parental status, nor the size of the dummy, was associated with their choices. Gender was significantly associated with the carriers' recommendations to parents, as more females recommended that parents pass the infant, $\chi^2(2, N= 4) = 6.49$, $p = .04$, especially those who carried the larger dummies. A summary of infant carrier comments is included in Appendix F.

Eighteen of the 48 (38%) carriers remarked that passing the infant dummy was time-consuming and required prior coordination with another passenger, and that a parent would never hand off his/her child to anyone other than another family member. Those who selected the passing maneuver for comfort, safety, and to recommend to parents, commented that the dummy (18/24-month size) was too heavy to carry through the exit and that they were concerned about injuries that might be incurred by striking the infant's head or limbs on the exit frame. Carrying orientations and maneuvers are illustrated in Figures 4 through 7.

The design of this experiment allowed individuals to carry the infant dummies through the Type III overwing exit in the manner that they chose on the first trial, to experience different carrying maneuvers on the next three trials, and to choose a maneuver on the final trial. On the first trial, when no instruction as to how to carry the infants was given, 34 (71%) chose to carry the dummies vertically, and 14 (29%) carried them horizontally. On the final trial, 31 (65%) of the infant carriers carried the dummies vertically, 14 (29%) carried the dummies horizontally, and 6% (3) chose to pass the dummy to another person. One each of the 6-, 18-, and 24-month dummies was passed, with the carriers changing from the vertical orientation on the first trial to passing on the last trial. An equal number (13%) changed from vertical to horizontal and horizontal to vertical. Sixty-seven percent used the same maneuver on the first and final trials. Of the 12 who changed between vertical and horizontal, 8 carried the 2- or 6-month dummies.

Results for Exit Type Comparisons

Smoke. The infant carriers' mean individual egress times and exit negotiation times for the Type III exit for each trial are included in Table 6. The effects of smoke were evaluated by comparing both time measures for the final trial with those measures for the first trial in clear air. Smoke did not significantly increase the time it took for infant carriers to approach or climb through the overwing exit. As a matter of fact, overall egress was faster for the final trial with smoke than for the first trial without smoke. Recall that both trials were uninstructed regarding carrying orientation/maneuver.

The infant carriers' mean individual egress times for the Type I floor-level exit evacuations are included in Table 7. The infant carriers took significantly longer to egress in smoke than in clear air, with a mean difference of about 1/3 second, $t(47) = 5.11$, $p < .001$. The time for the first trial was, however, significantly shorter than all the other trials, not just the smoke trial.

Comparison of egress *through both exits* reveals that, on the first trial, egress with infants through the Type III overwing exit was significantly slower than egress through the Type I floor-level exit, $t(94) = 4.29$, $p < .001$. In contrast, the individual egress times were essentially the same through both exit types on the final trial.

Infants and other passengers. The effect of egress with infants on the egress of other passengers was assessed by comparing the *individual egress times* of participants exiting just before the infant carriers, those exiting just after the carriers, and all other participants for each trial. The mean egress times for these evacuees did not differ significantly ($\bar{X}$ = 1.16, 1.14, 1.10 seconds, respectively). Participants exiting just before carriers were often the receiver for the passing maneuver, but that did not slow their egress. For participants in the Type I evacuations, the egress time for those exiting just after infant carriers ($\bar{X}$ = 1.48) was longer than for others who were not carriers ($\bar{X}$ = 1.20), but not significantly so. Participants immediately behind infant carriers were observed helping them sit down on the slide, but that assistance did not significantly slow group egress.

DISCUSSION

The results supported the expectation that carrying an infant dummy and climbing through the Type III overwing exit produces faster egress than passing the dummy through the exit to a person outside the airplane. Waiting for someone to help with the dummy proved to take more time than simply climbing through the exit and there was no guarantee that someone would take the infant dummy, unless the maneuver had first been coordinated. Those carriers who had difficulty climbing through the exit with the larger dummies on the instruction trials, and then actually used the passing maneuver on the final non-instructed trial, made a point of enlisting help from another evacuee in advance, thereby minimizing the exit negotiation time during the final trial in smoke. This *planning* strategy would not be apparent to the average passenger who has not been informed of its benefit.

The carriers' preference and recommendation of the vertical carrying orientation appeared to come from their concern for the infant's safety. Their comments revealed that they either thought they would, or actually did, strike some part of the infant dummy on the exit frame when carrying it horizontally, particularly with the larger dummies.

The ability to hold the dummy against themselves and to enfold and protect its head, arms, and legs was also important to the carriers. For the 2-month infant dummies, this could be accomplished with either the horizontal or the vertical orientation and was probably a matter of personal comfort for those carriers. Some of those who carried the largest and heaviest dummies reported that they had greater difficulty maneuvering through the exit with the dummy, however, and preferred the passing method. These statements confirmed the Degree-of-Ease ratings and underscored the carriers' selection of carrying orientation/maneuvers on the non-instructed final trial, as discussed above.

Comparing the individual egress times of the participants shows that egress with infants did not significantly influence the individual egress times of the other individuals evacuating through the overwing exit. Unfortunately, this does not speak to the addition of critical seconds to the evacuation time of the group as a whole. In an actual emergency, a delay caused by a parent waiting for someone to take his or her child could very well mean that passengers still in the plane would not survive. The impact of egress with infants on other passengers evacuating through the Type I exit was also shown to be negligible. While participants did occasionally help infant carriers into the sitting position to board the evacuation slide, the delays were minor. Such delays could become major in an actual evacuation, though, if a significant number of passengers sat to board the escape slide and they all required help.

The presence of smoke in the cabin did not appear to increase egress time for infant carriers. It is quite likely that, by the fifth and final trial, the infant carriers had become well practiced at maneuvering with the infant dummy to and through the exit. Previous research on egress through the Type III overwing exit has identified an asymptotic learning curve for speed of egress, where asymptote was achieved by the third trial (McLean & George, 1995; George & Corbett, 1999). This being the case, the infant carriers had probably become familiar enough with the weight and bulk of the infant dummies that they were able to simply follow the passenger queue to the exit and climb out, without the smoke-related decrease in visual perception significantly slowing their egress. Additionally, without instruction *requiring* a third of the carriers to pass their infants, only three chose to pass the infant outside. Thus, the infant carriers were able to select the carrying orientation/maneuver that best suited them on the final trial, likely resulting in more efficient egress.

Egress with infants through the Type III overwing exit was expected to be significantly slower, overall, than egress through the Type I floor-level exit. This was the case on the first trial when all infant carriers were evacuating the first time with the infant dummies and without any instruction as to how to manage the dummies. After experiencing several techniques for egress with the infant dummies, however, the infant carriers performed almost identically on the final trial, even with reduced visibility produced by smoke.

The mean egress times for each trial in the Type I evacuations give further support for identifying jumping onto the escape slide as the preferred and recommended boarding maneuver in Corbett (2001). In a pattern similar to that seen in the Type III trials, adding specific instructions for carrying orientation and boarding maneuver for the second through the fifth experimental trials increased the egress time over the first trial, probably because the sitting maneuver was *required* for half of the infant carriers. The third, fourth, and fifth trial times were progressively shorter than the second trial; this effect was likely due to progressive experience. The egress time for the final trial increased slightly over the fifth trial. While a further reduction in egress time on the last trial might be expected, the decreased visibility produced by the smoke appeared responsible for egress slowing, unlike egress times in the final Type III exit trial.

The increased egress time on the last trial of the Type I evacuations was almost a third of a second longer than that of the first trial, the only other non-instructed trial. One of the infant carriers elected to sit to board the slide on the first trial, and only four of the 48 carriers sat on the last trial. Thus, even with experience (and with a minimum of sitting), boarding the evacuation slide with an infant took longer in smoke. McLean et al. (1996) did not find such an effect of smoke on boarding the slide. In the design of their study, the smoke trial also followed the clear air trial. However, their participants were much less experienced than those in this study. Consequently, the "…delay produced by passenger queuing at the slide masked the smoke-induced slowdown" (p. 10). Here, the infant carriers had become very experienced at slide boarding, as indicated by the progressive reduction in egress time for the instructed trials, and the smoke effect is likely to have become more obvious as their hesitation times in boarding the slide were reduced.

The infant carriers' performance on the final trials of both experiments is a noteworthy demonstration of the beneficial effects of education and "hands-on" experience in airplane evacuations. Egress through the Type III exit appeared to benefit the most, which is particularly significant, as this small exit is the closest means of escape for as many as two-thirds of the passengers on many airplanes.

CONCLUSION

The results from previous research highlight the premise that the best chance passengers have of surviving an airplane accident is to be fully knowledgeable of, and especially proficient at, appropriate emergency procedures and behaviors. The more passengers know about the emergency situations they might encounter, and how to escape from them, the more likely they will be able to "make that perilous journey from seat to sanctuary" successfully (Snow, 1970).

This study examined evacuation procedures for which little or no information is currently being provided. To safely and efficiently evacuate with an infant from an airplane, it is necessary that the infant's head, neck, and limbs be protected. As asserted by Corbett (2001), protection would include cradling the infant's head and neck with the hand (for vertical positions) or in the arm (for horizontal positions), and keeping the infant's arms, legs, and feet enfolded as much as possible by the parent's arms. The size of the infant will likely dictate whether protection is best achieved by holding the child vertically or horizontally.

When evacuating by way of the Type III overwing exit, the infant carrier should climb quickly through the exit opening. If the size of the infant will inhibit egress through this small exit, and passing the infant is preferred, a strategy to accomplish this maneuver (i.e., "passing and receiving") should be planned well in advance of the need to evacuate. When evacuating by way of the Type I floor-level exit, jumping onto the escape slide is the preferred boarding maneuver (c.f. Corbett, 2001). These recommendations should be included in passenger education materials, training programs, safety cards, and pre-evacuation briefings.

It is known that passengers are not well-informed when it comes to emergency evacuation procedures, and they do not take steps to become more aware, e.g., attending to oral and written safety briefings (Corbett & McLean, 2004; Johnson, 1979). Therefore, future research should seek to identify the best methods for providing information about the techniques for "caring for precious cargo" during emergency aircraft evacuations.

REFERENCES

Aircraft Accident Investigation Branch (2003). McDonnell-Douglas MD-83, EC-FXI: Main document, Aircraft Accident Report No. 4/2003 EW/C2001/5/10. London: Department of Transport.

American Academy of Pediatrics (2001). *Policy Statement: Restraint use on aircraft*. Volume 108, Number 5, November 2001, pp. 1218-21. Available at http://www.aap.org/policy/re0101.html.

Baddeley, A.D. (2001). Selective attention and performance in dangerous environments. *Human Performance in Extreme Environments, 5*, 86-91.

Bordens, K.S. & Abbott, B.B. (1996). *Research design and methods: A process approach, 3rd Edition.* Mountain View, CA: Mayfield Publishing.

Chittum, C. (1998). *Caring for Precious Cargo.* Unpublished manuscript.

Corbett, C.L. (2001). *Caring for Precious Cargo, Part I: Emergency aircraft evacuations with infants onto inflatable escape slides* (DOT/FAA/AM-01/18). Washington, DC: Office of Aerospace Medicine.[1]

Corbett, C.L. & McLean, G.A. (2004). Passenger safety awareness: Still ignorant after all these years. *Aviation, Space and Environmental Medicine, 75*(Suppl.), B65.

Department of Transportation (1994a). Memorandum of Agreement between DOT and Department of Defense, U.S. Air Force, 552nd Air Control Wing, No. ACO289CM9. Washington, DC: FAA, Federal Air Surgeon, AAM-1.

Department of Transportation (1994B). Memorandum of Agreement between DOT and Department of Defense, U.S. Navy, Strategic Communications Wing One, No. ACO302CM9. Washington, DC: FAA, Federal Air Surgeon, AAM-1.[1]

Department of Transportation (1998). *Child Restraint Systems* (Advanced notice of proposed rulemaking, Notice No. 98-2). Federal Register: February 18, 1998, Vol. 63, No. 32, pp. 8323-8. Available at http://www.access.gpo.gov/su_docs.

Fritz, C.E. & Marks, E.S. (1954). The NORC studies of human behavior in a disaster. *Journal of Social Issues, 10,* 26-41.

Garner, J.D. & Blethrow, J.G. (1966). *Emergency evacuation tests of a crashed L-1649* (AM-66/42). Washington, DC: Office of Aviation Medicine.[1]

George, M.H. & Corbett, C.L. (1999) Effects of cabin crew location and passenger motivation on aircraft evacuations. *Proceedings, 1998 International Aircraft Fire and Cabin Safety Research Conference, November 16-20, 1998, Atlantic City, NJ* (DOT/FAA/AR-99/68). CD-ROM (Federal Aviation Administration, European Joint Aviation Authorities, Transport Canada Civil Aviation, Japanese Civil Aviation Bureau, 1999). Washington, DC: FAA.

Hynes, M.K. (1999). *Frequency and costs of transport airplane precautionary emergency evacuations* (DOT/FAA/AM-99/30). Washington, DC: Office of Aviation Medicine.[1]

Hynes, M.K. (2000). *Evacuee injuries and demographics in transport airplane precautionary emergency evacuations* (DOT/FAA/AM-00/11). Washington, DC: Office of Aviation Medicine.[1]

Johnson, D.A. (1979). *An investigation of factors affecting aircraft passenger attention to safety information presentations.* Washington, DC: DOT. (NTIS No. ADA082358)

Johnson, D.A. (1997). How people behave in aircraft accidents. *Human Performance in Extreme Environments, 2,* 71-80.

McLean, G.A., Corbett, C.L., Larcher, K.G., McDown, J.R., Palmerton, D.A. Porter, K.A., Shaffstall, R.M., & Odom, R.S. (2002). *Access-to-egress I: Interactive effects of factors that control the emergency evacuation of naïve passengers through the transport airplane Type-III over-wing exit* (DOT/FAA/AM-02/16). Washington, DC: Office of Aerospace Medicine.

McLean, G.A., & George, M.H. (1995). *Aircraft evacuations through Type-III exits II: Effects of individual subject differences* (DOT/FAA/AM-95/25). Washington, DC: Office of Aviation Medicine.[1]

McLean, G.A., George, M.H., Funkhouser, G.E., & Chittum, C. B. (1996). *Aircraft evacuations onto escape slides and platforms I: Effects of passenger motivation* (DOT/FAA/AM-96/18). Washington, DC: Office of Aviation Medicine.[1]

[1]This publication and all Office of Aerospace Medicine technical reports are available in full-text from the Civil Aerospace Medical Institute's publications Web site: http://www.cami.jccbi.gov/aam-400A/index.html

McLean, G.A., Higgins, E.A., Lyne, P.J., & Vant, J.H. (1989). *The effects of wearing passenger protective breathing equipment on evacuation times through Type III and Type IV emergency aircraft exits in clear air and smoke* (DOT/FAA/AM-89/12). Washington, DC: Office of Aviation Medicine.[1]

National Transportation Safety Board (2000). *Emergency Evacuation of Commercial Airplanes,* Safety study NTSB/SS-00/01. Washington, DC: NTSB.

Quarantelli, E.L. (1954). The nature and conditions of panic. *American Journal of Sociology, 60,* 267-75.

Shiffrin, R.M. & Schneider, W. (1977). Controlled and automatic human information processing: II Perceptual learning, automatic attending, and a general theory. *Psychological Review 84*(2), 127-90.

Snow, C.C., Carroll, J.J., & Allgood, M.A. (1970). *Survival in emergency escape from passenger aircraft* (DOT/FAA/AM70-16). Washington, DC: Office of Aviation Medicine.[1]

Weisaeth, L. (1986). Human stress reactions and their relationship to survival in a catastrophe. *Training for Survival and Rescue at Sea.* Proceedings of the IASST Conference: Aberdeen, Scotland, 1986.

FIGURES

Figure 1. Test area shows Type III overwing exits and padded egress route. A canvas "hatch" was opened by a research team member.

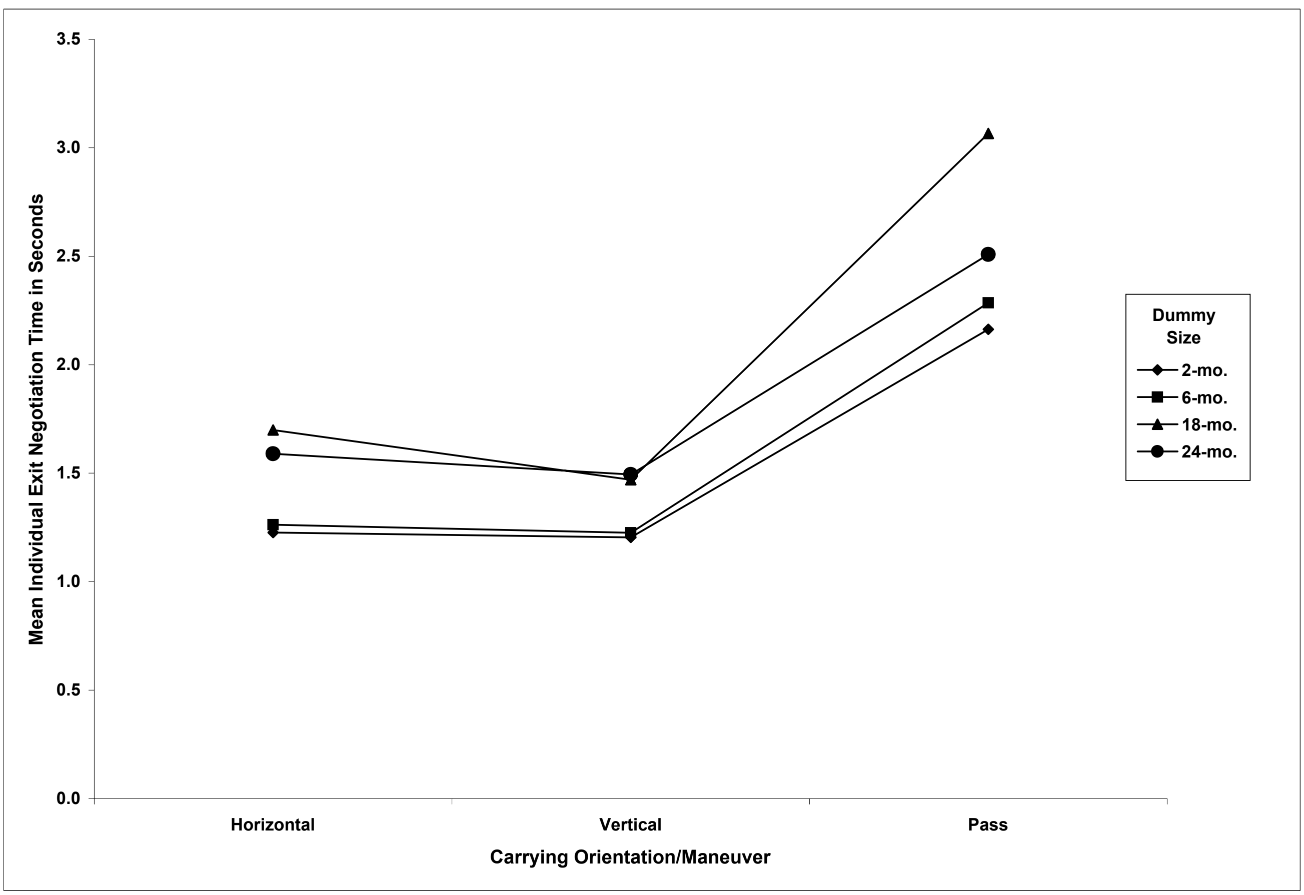

Figure 2. Speed of Egress Main Effect for Carrying Orientation and Dummy Size.

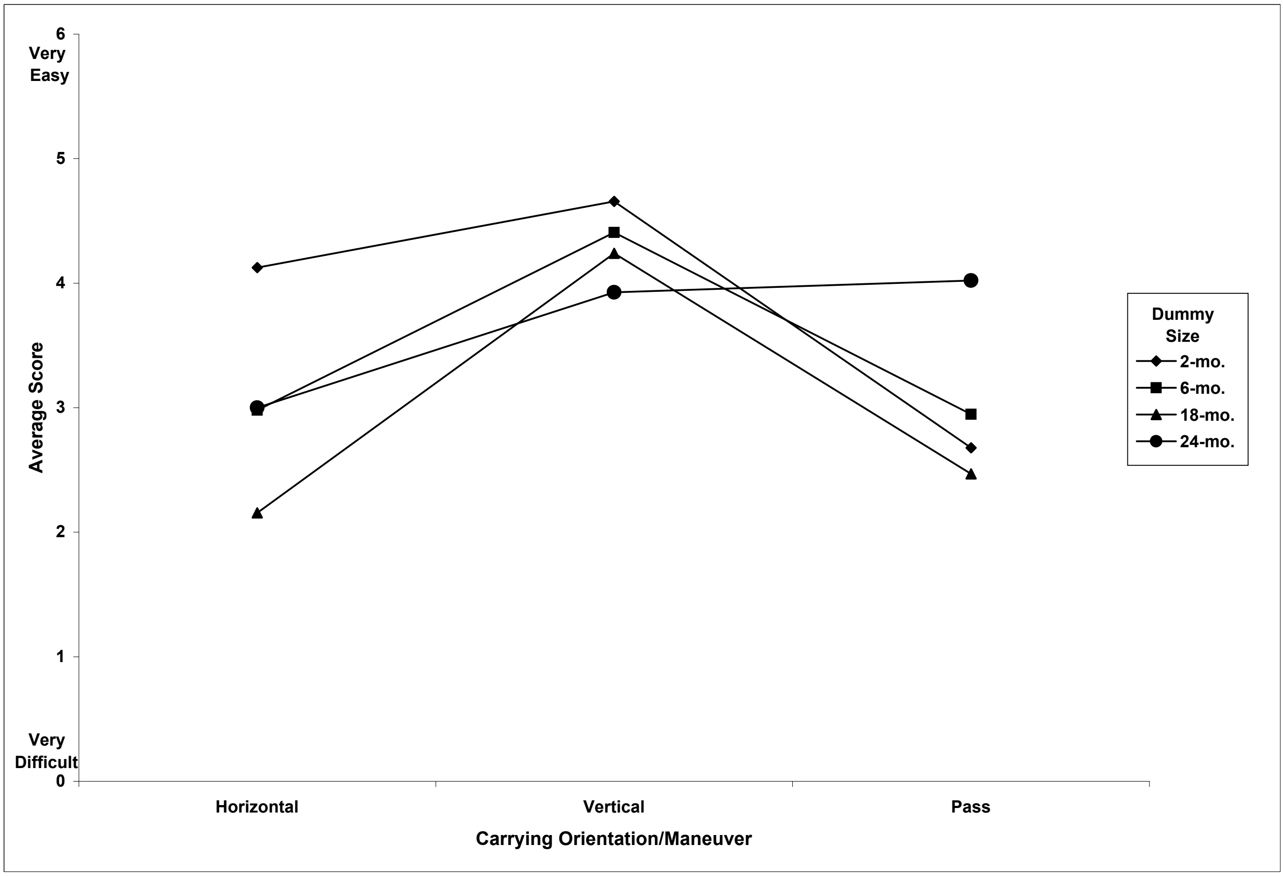

Figure 3. Degree of Ease Main Effect for Carrying Orientation

Figure 4. Infant carrier holds 18-month dummy horizontally and steps through the exit.

Figure 5. Infant carrier holds 2-month dummy horizontally as she climbs through the exit.

Figure 6. The head and neck of two 18-month dummies are well supported by infant carriers as they hold the infants vertically while evacuating.

Figure 7. A 24-month dummy is passed through the overwing exit.

TABLES

Table 1.
Infant Anthropometry

Age in months	Mean Weight/kg	s.d.	Weight range/lb	Mean Length/cm	s.d.	Length range/in
0 – 2	5.1	1.1	8.82 - 13.67	56.3	3.9	20.64 - 23.71
3 – 5	6.9	1.0	13.00 - 17.42	63.1	3.6	23.42 - 26.26
6 – 8	8.1	0.9	15.88 - 19.84	68.5	2.6	25.95 - 27.99
9 – 11	9.2	1.1	17.85 - 22.71	73.0	3.3	27.44 - 30.04
12 – 15	10.1	1.2	19.62 - 24.92	76.5	3.2	28.93 - 31.45
16 – 19	10.6	1.2	20.72 - 26.02	79.2	3.4	29.84 - 32.52
20 – 23	11.5	1.5	22.04 - 28.66	82.6	4.0	30.92 - 34.08
24 - 42	14.1	1.9	26.89 - 35.27	93.4	5.0	34.80 - 38.74

Note. From "Anthropometry of infants, children, and youths to age 18 for product safety design, Final Report, May 31, 1977," Highway Safety Research Institute, The University of Michigan, Ann Arbor, Michigan 48109. Richard G. Snyder PhD, Lawrence W. Schneider PhD, Clyde L. Owings MD PhD, Herbert M. Reynolds PhD, D. Henry Golomb MS, M. Anthony Schork PhD.

Table 2.
Dummy measurements

Dummy number	Weight/lb	Length/in	Estimated age representation
1	10.91	16.75	2 months
2	10.51	16.75	2 months
3	17.04	24.50	6 months
4	18.06	26.00	6 months
5	24.76	33.00	18 months
6	25.65	31.00	18 months
7	28.96	31.00	24 months
8	29.92	31.00	24 months

Table 3.
Analysis of Variance for Speed-of-Egress
Type III Over-wing Exit

Source	*df*	*F*	η^2	*p*
		Between Subjects		
Dummy Size (D)	3	3.62	.20	.02
Error	44	(0.21)		
		Within Subjects		
Carrying Orientation/ Maneuver (C)	2	34.40	.44	<.001
C x D	6	0.49	.03	.82
Error (C)	88	(0.58)		

Note. Mean square errors are in parentheses.

Table 4.
Analysis of Variance for Degree-of-Ease
Type III Over-wing Exit

Source	*df*	*F*	η^2	*p*
		Between Subjects		
Dummy Size (D)	3	2.161	.13	.11
Error	44	(2.33)		
		Within Subjects		
Carrying Orientation (C)	2	9.52	.18	<.001
C x D	6	1.81	.11	.11
Error (C)	88	(2.67)		

Note. Mean square errors are in parentheses.

Table 5.
Distribution of Responses to Emergency Aircraft Evacuations With Infants Survey
Type III Over-wing Exit

Carrying Orientation/ Maneuver	Dummy Size				
	2 months	6 months	18 months	24 months	Total
Which maneuver was the most comfortable?					
Hold infant vertically	7	9	8	6	30
Hold infant horizontally	4	3	1	2	10
Pass infant through exit	1	0	3	4	8
Total:	12	12	12	12	48
Which maneuver do you think is safest for the infant?					
Hold infant vertically	7	7	8	7	29
Hold infant horizontally	4	2	1	1	8
Pass infant through exit	1	3	3	4	11
Total:	12	12	12	12	48
Which maneuver would you recommend to parents?					
Hold infant vertically	7	7	8	7	29
Hold infant horizontally	4	2	1	2	9
Pass infant through exit	1	2	3	3	9
Total:	12	11*	12	12	47

*One carrier did not answer this question

Table 6.
Infant Carrier Egress Time
Type III Over-wing Exit

Trial	Exit Negotiation		Individual Egress	
	Mean Time In Seconds	*SD*	Mean Time In Seconds	*SD*
Trial 1: Without instruction	1.50	.40	1.82	.46
Trial 2: With instruction	1.86	1.04	2.18	1.07
Trial 3: With instruction	1.74	.87	2.01	.89
Trial 4: With instruction	1.67	.94	2.00	.97
Trial 5: Without instruction With smoke	1.43	.34	1.75	.50

Table 7.
Infant Carrier Individual Egress Time
Type I Floor-level Exit

Trial	Mean Time In Seconds	*SD*
Trial 1: No instruction	1.39	.52
Trial 2: With instruction	1.79	.59
Trial 3: With instruction	1.74	.57
Trial 4: With instruction	1.68	.57
Trial 5: With instruction	1.59	.59
Trial 6: No instruction With smoke	1.70	.65

APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE FOR TYPE III EXIT EVACUATIONS

Participant number: ____________________(First and last initials, and last for digits of SSN)

Do you have any physical disabilities, i.e. back, neck, arms, legs?___________

Are you capable of climbing through a Type III over-wing exit with a 30 pound dummy? ______

Sex: Male _______ Female _______

Age: ________ Height: ________ Weight: ________

Do you have children? ________ If yes, what is/are their age(s)? ________________________

Have you ever participated in an evacuation exercise here at CAMI before? Yes No

Highest year of education completed: 12 13 14 15 16 17 18 19 20

For Researcher Use: Infant dummy # __________ Vest # ____________

APPENDIX B

INDIVIDUAL'S CONSENT TO VOLUNTARILY PARTICIPATE IN A RESEARCH PROJECT

(Type III overwing exit in clear air and smoke)

I, ____, understand that this research project entitled *Emergency Aircraft Evacuations with Infants* is being sponsored by the Federal Aviation Administration (FAA) and is being directed by Cynthia L. Corbett of the Civil Aeromedical Institute (CAMI), under the supervision of G. A. McLean, PhD. I am an attendee of CAMI's Military Egress Training/Cabin Safety Workshop and volunteer of my own free will to participate in the project.

PURPOSE: I understand that this project is designed to look at ways to improve aircraft safety. The specific areas of concern are evacuating through a Type III overwing exit while carrying an infant dummy. The project is designed to identify the fastest and safest way to evacuate an aircraft under emergency conditions while carrying an infant.

DESCRIPTION OF STUDY: I understand that this research will be conducted in the CAMI Aircraft Cabin Evacuation Facility (ACEF), and will involve military or workshop personnel, who will be required to evacuate the simulator cabin as many as six times. I understand I will be seated in the simulator holding an infant dummy and when the start signal is given I will evacuate the facility, as instructed, as quickly and safely as possible. I understand that it is important to follow the instructions given by the research team. Between trials, I will remain outside of the simulator until receiving instructions from the research team. I understand that all of the trials that I participate in will be videotaped.

RISKS: I understand that there are possible injuries I could receive from my participation in this study. Such injuries could include, but are not limited to, bruises, lacerations, strains, sprains and/or broken bones. These usually result from slipping, tripping, or falling. In previous studies at this facility the most serious injuries have been lacerations, contusions, strains, sprains, and broken bones. These were principally caused by lack of subject attention, and participation by subjects whose day-to-day activities do not include physical exertion. The estimated incidence of such injuries is typically less than one per 100 performing evacuations using a Type III overwing exits. I have been briefed and shown pictures and videos about how to properly accomplish these activities, and I have had opportunities to ask any questions I have concerning the research and my participation. All of my questions have been answered to my satisfaction.

Participant's Initials __________________

PARTICIPANT'S RESPONSIBILITIES: I certify that I have no physical disabilities that would prevent me from being able to evacuate an aircraft cabin, nor any illnesses such as heart disease, or other conditions, such as pregnancy, that restrict my ability to exercise, move nimbly, or which could make this activity additionally hazardous.

I further certify that I am **NOT** under the influence of any medication or chemical substance, including alcohol, that may compromise my own safety or the safety of others directly associated with the research. I also acknowledge that I must withdraw **NOW** from participation in the project if I have any such condition or am under any such influence.

I understand that it is important to be accurate and honest with my responses on the subject questionnaires and any other questions the researchers may have about the research and my participation during the project.

I understand that it is very important to pay attention and follow all instructions from the researchers. I hereby release the FAA from any and all claims that may arise as the result of my own negligence and/or failure to follow the instructions of the CAMI personnel.

Participants's Initials _________________

CONFIDENTIALTY: I agree to allow still photographs and/or videotapes to be made of me as required during the research, with the understanding that these records are the property of the U. S. Government, and that I am not entitled to monetary or other benefits, now or in the future, for the use of this material. I understand that all records of this study will be kept confidential, and that I will not be identified by name or description in any reports or publications about this study, except where photographs may include my picture.

Participant's Initials ________________

BENEFITS: The major benefit to me will be the satisfaction of participating in a project that will improve passenger safety on commercial aircraft. The FAA will have a documented account of evacuating aircraft with adults carrying infants. This will allow the FAA to provide guidance to the airline industry on how carried infants should be held when evacuating aircraft in states of distress. These procedures could reduce severe injuries and deaths to young infants involved in aircraft accidents.

COMPENSATION AND INJURY: I have been made aware that accident insurance coverage for this activity will be provided by the military health care system or my employer. I have been made aware that my personal accident insurance might not cover me while I am on duty. I have been made aware that necessary immediate care of any resultant medical problems may be provided by the CAMI Clinic until, or unless, transportation to another medical facility is obtained. Follow-on care would be provided by local clinics and hospitals that would require verification of my insurance. I agree to provide CAMI, if requested, with copies of all insurance and medical records arising from any such care for injuries/medical problems.

Participant's Initials __________________

SUBJECT'S ASSURANCE: I understand that my participation in this project is voluntary. I have not given up any of my legal rights or released any individual or institution from liability for negligence. **<u>I understand that I may withdraw from this project at any point during or between trials</u>**. I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed.

Participant's Initials __________________

I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I understand that I may request a copy of this consent form. If I have <u>questions</u> about this study, or need to report any adverse effects from the research procedures, I will contact Ms. Corbett at (405) 954-7528.

Do you understand that participation in this research project involves risk of injury and that there are things you can do to reduce that risk? (Initial one) Yes __________ No __________

______________________________________ _____________

Research Participant's Signature Date

______________________________________ _____________

Investigator Date

______________________________________ _____________

Witness Date

APPENDIX C

Emergency Aircraft Evacuations With Infants Survey

Participant number: _________________ (First and last initials, and last four digits of SSN)

Indicate the degree of ease or difficulty of evacuation for each maneuver by marking an "X" on the scale:

1. Holding infant *vertically*

|____|
Very difficult Very easy

2. Holding infant *horizontally*

|____|
Very difficult Very easy

3. Passing infant through the exit

|____|
Very difficult Very easy

Circle your answer to the following questions:

5. Which maneuver was the most comfortable?

   a. Holding infant *vertically*
   b. Holding infant *horizontally*
   c. Passing the infant through the exit

6. Which maneuver do you think is safest for the infant?

   a. Holding infant *vertically*
   b. Holding infant *horizontally*
   c. Passing the infant through the exit

7. Which maneuver would you recommend to parents?

   a. Holding infant *vertically*
   b. Holding infant *horizontally*
   c. Passing the infant through the exit

Remarks: ____

____

APPENDIX D

INITIAL SUBJECT BRIEFING
Overwing Exit groups

Today you will participate in a research project designed to investigate the safest way to evacuate an aircraft to improve safety in air travel. Your participation is greatly appreciated, and of the utmost importance. You can take a great deal of satisfaction in knowing that the results of your actions today may save lives and reduce serious injuries to small children traveling on aircraft. You will be required to perform six evacuations using the Type III overwing exit. The opening for the exit is approximately 38” high and 20” wide. The sill of the exit is approximately 19” above the floor and 27” above the ground outside. On five of the evacuations some of you will carry an infant dummy weighing between 10 and 30 lbs.

To participate in the trials today, you must not have any physical disabilities that would prevent you from moving freely and stepping through the overwing exit. And - you must ***NOT*** have any illness that would restrict your ability to exercise such as heart disease, or other conditions such as pregnancy. You cannot be under the influence of alcohol or any drug, including some prescription drugs. If you have any questions about medical or physical conditions, or the use of medications, one of the members of the research team will answer them. You can decide at any time not to participate in the project.

Although injury risks are minimal, there is a possibility of injuries, which may include, but are not limited to: bruises, lacerations, strains, sprains and/or broken bones. The estimated incidence of such injuries is typically less than one per 100 people performing evacuations using the Type III overwing exit. These usually result from slipping, tripping, or falling. In previous studies at this facility the most serious injuries have been lacerations, bruises, strains, sprains, and broken bones. These were principally caused by lack of subject attention to the task at hand, and participation by subjects whose day-to-day activities do not include physical exertion.

Members of the research team are providing you with an informed consent form. This document will let us know that you have been told about the tests, understand the procedures, and are willing to participate. I will read the consent form aloud, and answer any questions you may have. Also - remember that you may withdraw from the tests at any time.

Turn in your consent form and you will get your vest.

Once you get your baby and/or vest, you may go down the west staircase and meet at the doors. Baby carriers, carry your babies outside and place them on the cart. Wait for Jerry before you board the simulator.

APPENDIX E

SAFETY BRIEFING FOR TYPE III EXIT
Deliver just before trials, inside the simulator

The experiment that we are conducting today is very important to the future of aviation safety. You will be required to perform six group evacuations through an exit 38 inches high by 20 inches wide. The sill of the exit is 19” above the oor and 27” above the ground outside. On five of those evacuations some of you will have to carry an infant dummy that weighs between 10 and 30 lbs. The researchers will advise you about the evacuation procedure for each experimental trial.

When you hear this buzzer (sound buzzer), get up and exit the facility, carrying the dummy, as quickly and safely as possible. Please handle the dummy as carefully as you would a human infant.

Should an unsafe condition occur, this bell will ring (sound bell). If the bell rings, stop all movement and wait for instructions. The bell will also ring at the end of each trial.

You will be videotaped while participating in this research. Please move away from the area outside the exit as soon as you are through the exit. Do not obscure the video cameras.

You are free to withdraw from this experiment at any time.

APPENDIX F

Summary of Infant Carrier Remarks from
Emergency Aircraft Evacuations With Infants Survey

"Horizontal doesn't work for a larger baby"

"Horizontal, vertical depends on size of baby. When I held my infant vertically, I knocked its head on the exit!"

"A parent would never pass their child to another person."

"My baby was long so it was easier to carry horizontal. When I carried her vertically, her head kept getting caught and I could not distribute weight as well."

"Suggest assigning an able-bodied person/buddy to assist parent. Vertical is most natural for small infant, holding head in hand, much like brace position recommended by many airlines."

"Passing the baby and getting them out first was the easiest; otherwise, the baby's head can hit on the exit frame."

"The baby will get his/her head injured in the horizontal position."

"Passing the baby to someone else takes time and prior coordination."

"If horizontal, you need to tuck head under arm to protect."

"I told the person exiting ahead of me to grab my baby once outside and he ran off. This was only simulated. I can imagine that an untrained person faced with an emergency would be too consumed with self-preservation and maybe panic to have the desire to help you or even comprehend your request. I think any attempt to do this would delay evacuation and could add to the confusion."

"Holding vertically for infants is good, but with larger children, it can be difficult."

"Holding infant horizontally was much more awkward. Infant dummy's arm was dislodged from socket from catching on frame of exit."

"Passing the larger infant was easier, though time consuming."

"Hold vertical. Can protect head with one hand and maneuver legs with other in case of a large child."

"Vertically allows for baby to turn with parent's torso. Horizontally takes longer due to having to turn baby through door, then exiting."

"Passing the infant slows the evacuation for other passengers."

"With the larger baby, it was too easy to injure his head or limbs going through the exit. Recommend passing."

"Didn't think it was going to be so hard to travel with an infant and go through an evacuation."