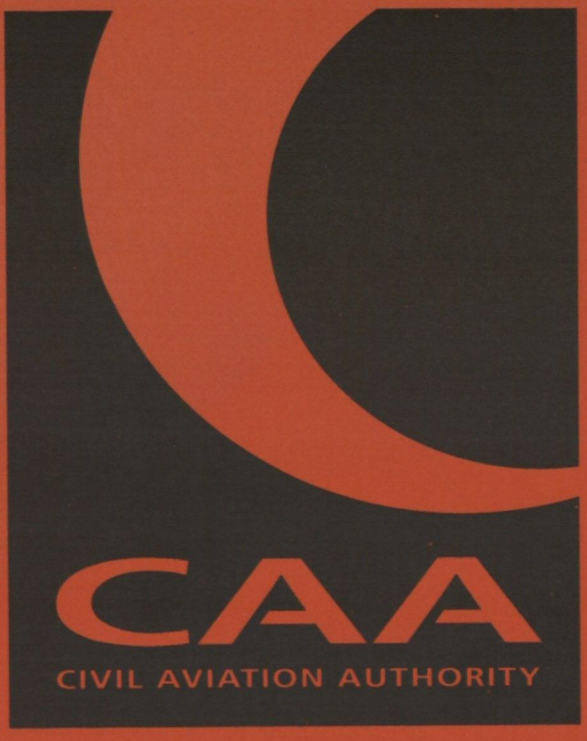

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Summary

The UK Civil Aviation Authority (CAA) commissioned the Applied Psychology Unit at Cranfield Institute of Technology to conduct an investigation in two separate phases in order to assess the influence of hatch weight and seating configuration on the ability of members of the public to operate a Type III hatch. The research was part of a wider European programme of Type III hatch testing which included tests conducted at Fokker in the Netherlands. Phase 1a assessed the influence of three alternative weights of hatch (12.5kg, 15kg and 25kg) on the ease of operation of the Type III exit in a pre-AN79 seating configuration. Phase 1b assessed the influence of the same three hatch weights with the seats arranged in accordance with Airworthiness Notice No. 79 (AN79, Ref. 1) to enable the effect of the increased seat space available from the AN79 seating configuration to be evaluated. In accordance with CAA testing criteria, fifty per cent of all the tests in Phase 1a and 1b were conducted with a 50th percentile male dummy, simulating a passenger unable to operate the exit. An assessment of the potential benefits of training members of the public to operate a Type III hatch was also included in Phase 1b.

One hundred and ninety two volunteers, 48 males and 48 females, took part in each phase of the investigation. Volunteers were representative of the 0-50th percentile population range and participated in individual tests aboard a Boeing 737 cabin mock-up. An emergency situation was simulated in which each volunteer was required to operate a Type III hatch and to evacuate through the exit onto the wing. Volunteers in Phase 1a operated the hatch once only whereas those in Phase 1b operated the hatch on three separate occasions.

The results indicated that it was necessary to have a 50% reduction in hatch weight from 25kg in addition to increasing the seat space available from the pre-AN79 to the AN79 seating configuration in order to significantly reduce the times taken to operate the hatch with or without a dummy obstructing the exit. The combined benefits of reduction in hatch weight and increased seat space were of significantly greater benefit to females than males. The results indicate that both a reduction in hatch weight and an increase in seat space are necessary for significant improvements in the times taken by passengers to operate the Type III exit to be achieved.

Practising the task three times significantly reduced the times taken by volunteers to operate the hatch and evacuate onto the wing in the conditions with the dummy present although no significant reduction in operation times was observed in the conditions without a dummy present. Practice gave volunteers the opportunity to learn and develop the necessary technique to enable them to open the hatch and manoeuvre it in the limited space available. Practice also helped volunteers to realise that the hatch should be placed outside the cabin in order to keep the access clear for other passengers.

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1 INTRODUCTION

In early 1991, the UK Civil Aviation Authority commissioned the Applied Psychology Unit at Cranfield Institute of Technology to conduct an investigation in order to assess the influence of hatch weight and seating configuration on the ability of members of the public to operate a Type III hatch. The investigation was conducted in two separate phases and assessed the ability of the lowest 50th percentile of the population to operate a Type III hatch. The investigation included an assessment of the potential benefits of training.

1.1 Background

The weight and awkwardness of the Type III hatch had been criticised as a result of problems encountered by passengers operating a hatch of this type in the accident which occurred at Manchester in 1985 and the collision between a Metroliner and a Boeing 737 at Los Angeles in 1991 (Ref. 2). The report into the Los Angeles accident criticised the narrowness of the exit row aisle in the Boeing 737 for delaying the operation and disposal of the hatch.

1.2 Exit row seating policy

Exit row seating recommendations specify that UK operators ensure that 'THE SEATS WHICH FORM THE ACCESS ROUTE from the cabin aisle to the exit are only to be allocated to passengers who appear physically capable of operating and/or assisting with the operation of the exit' (Ref. 3). According to this requirement handicapped passengers (including the blind and deaf), children and infants, frail, elderly or obese passengers, deportees or prisoners in custody are not allowed to occupy these seats as they could obstruct or delay evacuation in an emergency. The objective behind these recommendations is to ensure that passengers are able to operate and evacuate through the Type III exit in a timely manner. Unfortunately, there is no guarantee that obstructions can be prevented as sometimes passengers may become incapacitated as a result of the accident or incident which leads to the requirement for the emergency evacuation. Incapacitation may not always be due to injury but may sometimes be a negative form of panic in which the individual freezes and is unable to move (Ref. 4). This may possibly be due to fear or uncertainty regarding the nature of the situation. In the event of the passenger seated adjacent to the Type III hatch becoming incapacitated and causing an obstruction, other passengers would then be required to operate and dispose of the hatch.

1.3 The operation of the Type III hatch

The majority of Type III hatches are large and heavy and can be awkward to manoeuvre. For example, the overall measurements of a typical Boeing 737 hatch (including flanges) are 24.25 inches (61.5cm) by 39.75 inches (101cm) with an average weight of 22kg. Even passengers who are physically capable of operating a Type III hatch could be expected to experience difficulties in a crowded aircraft in an emergency. Evidence from aircraft accidents in which passengers have been required to operate a Type III exit supports these concerns: for example, a female passenger seated adjacent to a Type III hatch in the Manchester accident mistakenly tried to open the hatch using the armrest of her seat (Ref. 5). A fellow passenger assisted her but she became trapped underneath the opened hatch. Eventually it was removed from on top of her and placed on a seat in the row behind by a male passenger. In the collision between two aircraft which occurred at Los Angeles in 1991 the female

passenger seated immediately adjacent to the Type III exit froze and was unable to move (Ref. 6). A male passenger climbed over the seat and operated the hatch which was stowed on the seat in the exit row partially obstructing the exit. Previous research has identified that there may be benefits in demonstrating the method of operation of the Type III hatch to passengers, and providing them with the opportunity to practice opening the hatch (Ref. 7). However, the problems experienced by passengers attempting to operate the hatch were not identified in this study.

UK operators attempt to seat physically fit or able bodied passengers adjacent to the Type III hatch in accordance with NTAOCH 5/90 (Ref. 3). However, the size and weight of the Type III hatch may mean that passengers who are of a small stature could be exceeding their maximum lifting capacity if they were required to operate the hatch (Ref. 8). Consequently, it could be expected that these passengers may lack the physical strength necessary to operate the hatch quickly and that they could be expected to experience more problems operating and handling the Type III hatch than taller and physically stronger passengers. An investigation of the problems experienced by passengers of a generally small stature whilst operating and disposing of the Type III hatch could therefore be expected to indicate the nature of the most severe difficulties likely to be experienced by passengers in an emergency.

Identification of these problems led the CAA to commission the APU at the Cranfield Institute of Technology to investigate the influence of reductions in the hatch weight on the ability of members of the public to operate a Type III hatch. The investigation included an assessment of the influence of increasing the space between the rows immediately adjacent to the Type III hatch from the pre-AN79 to the AN79 seating configuration. It was a requirement of the study that the tests be conducted with an incapacitated passenger in the seat immediately adjacent to the Type III hatch in compliance with criteria for testing adopted by the CAA. This testing criteria had been established as a consequence of the failure of the passenger seated immediately adjacent to the Type III hatch to be able to operate the exit in more than one major accident (Refs. 5 and 6). As people who were smaller than average height and weight could be expected to experience the most difficulties in operating a Type III hatch it was a requirement of the test that only members of the public representative of the 0–50th percentile population should be recruited.

1.4 Objectives

The objectives of the study were to investigate the influence of hatch weight and seating configuration on the operation of a Type III hatch and to assess the potential benefits of practice. The study was conducted in two separate phases, referred to as Phase 1a and Phase 1b. The objectives of the two phases of the research programme are described as follows:

Phase 1a

(i) to assess the influence of hatch weight on the ease of operation of the Type III hatch in a pre-AN79 seating configuration

Phase 1b

(i) to assess the influence of hatch weight on the ease of operation of the Type III hatch in an AN79 seating configuration

(ii) to determine the influence of seating configuration on the ease of operation of the Type III hatch

(iii) to identify the potential benefits of training members of the public in operating the Type III hatch

2 METHOD

2.1 Research design

Volunteer members of the public were recruited to take part in a research programme in which each volunteer was required to operate a Type III hatch. In Phase 1a, each volunteer was required to operate the hatch once only. In Phase 1b, each volunteer operated the hatch on three separate occasions. In order to assess the influence of the weight of the hatch on its ease of operation, three weights of hatch (12.5kg, 15kg and 25kg) were utilised in the tests. A 50th percentile male dummy was seated immediately adjacent to the exit in half the tests in order to assess the influence of an incapacitated passenger on the ability of volunteers to operate this exit.

Table 1 shows the experimental conditions utilised in both Phases 1a and 1b in order to assess the influence of hatch weight, seating configuration and the presence of an incapacitated passenger. A total of 192 volunteers participated (96 in Phase 1a and 96 in Phase 1b) with equal numbers of males and females in each condition as indicated in Table 1.

Table 1 The experimental test conditions

	Phase 1a – Pre-AN79				*Phase 1b – AN79*			
Hatch weight (kg)	*Dummy present*		*No Dummy present*		*Dummy present*		*No Dummy present*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
12.5	8	8	8	8	8	8	8	8
15.0	8	8	8	8	8	8	8	8
25.0	8	8	8	8	8	8	8	8

2.2 Equipment

(i) *The cabin mock-up*

The experimental tests for both phases of the study took place on board the Boeing 737 cabin mock-up in the College of Aeronautics at Cranfield. The fittings inside the cabin mock-up were designed to simulate a Boeing 737 interior. Five rows of three seats were located along either side of the cabin fuselage. A fully functioning Type III hatch was fitted half way down the left hand side of the fuselage (refer to Figure 1, Appendix 1).

(ii) *The seating configuration*

Phase 1a

The two seat rows adjacent to the hatch were arranged in a pre-AN79 configuration (see Figure 2 in Appendix 2) in accordance with FAR/JAR 25, part .813 (Ref. 9), in which it is stated that the seats must not cause an obstruction to the operation of the hatch.

Phase 1b

The two seat rows adjacent to the hatch were arranged in accordance with AN79, paragraph 4.1.1 (Ref. 1) which states:

> 'Where seats are arranged such that there is a single access route between seat rows from the aisle to the exit, access shall be sufficient width and located fore and aft so that no part of any seat that is beneath the exit extends beyond the exit centre line. In any case, the access between seat rows vertically projected, shall not be less than half the exit hatch width, including any trim, or 10 inches, whichever is the greater.'

In the cabin mock-up, the seats fore and aft of the Type III exit hatch were at a seat pitch of approximately 38 inches (97 cm) with a vertical projection between the seats of 13 inches (33mm) as illustrated in Figure 3, Appendix 3.

(iii) *The Type III hatch*

The dimensions of the Type III hatch on the mock-up were a simulation of those on a Boeing 737 aircraft. The overall dimensions of the hatch including the flanges were 24.3 inches (61.5cm) by 39.8 inches (101cm). The dimensions of the outer aperture of the fuselage were 20 inches (50.8cm) by 38 inches (96.5cm) which was smaller than the inner aperture which measured 23.3 inches (59cm) by 38.5 inches (97.8cm). The vertical step-up height from the floor to the bottom of the exit inside the cabin was 13.5 inches (34.4cm), identical to that of a Boeing 737 aircraft. The step-down height from the bottom of the door onto the wing was 15 inches (38cm) which is considerably less than the maximum 23 inches (58.5cm) allowed (Ref. 10).

The interior appearance of the hatch differed from that on a standard Boeing 737 only with respect to the protective guard over the handle which had been removed. In all other respects the handle mechanism operated in the conventional manner. In accordance with the Type III hatch operating instruction requirements (Ref. 9) the word 'PULL' was written in red above the handle mechanism and at the top of the hatch there was a red arrow pointing downwards on either side of the handle.

The external appearance of the hatch differed from that of a standard Boeing 737 hatch in that it was of an open construction enabling weights to be attached to the inside of the hatch in order to increase its overall weight from the minimum weight of 12.5kg to 15kg and 25kg. The outer surface of the hatch was then entirely sealed with a black plastic cover to prevent volunteers from using the open framework to assist in its operation.

Also in accordance with AN79 requirements (Ref 1), typical safety placards, based on airline safety cards and illustrating the operating instructions of the exit currently existing on Boeing 737 aircraft, were located on the back of each seat in the row forming the access to the exit (see Figure 4 in Appendix 4). Boeing 737 safety cards were also located in the seat pockets.

2.3 Data acquisition

Two video cameras were located inside the cabin in order to record the manner in which the volunteers opened and disposed of the hatch. Two additional video cameras were located on the wing outside the Type III hatch also allowing the manner in which volunteers disposed of the hatch to be recorded. Figure 1 in Appendix 1 shows the locations of the video cameras. All four cameras were fitted with a timebase function and microphones to facilitate analysis.

2.3.1 *Phase 1a – pre-AN79 seating configuration questionnaire*

A short questionnaire was used to identify any problems experienced by the volunteers whilst opening and disposing of the hatch and evacuating onto the wing (see Appendix 5). In this questionnaire, volunteers were asked to assess (using a seven point scale) the ease with which they considered that they had been able to open the exit and evacuate from the cabin and to indicate the nature of any difficulties which they had experienced in completing this task. Volunteers were also asked to indicate the number of times that they had flown as an airline passenger and whether they had previously experienced an aircraft emergency. Finally, in order to obtain some measure of physical fitness, each volunteer was asked to indicate how frequently they carried out strenuous physical exercise.

2.3.2 *Phase 1b – AN79 seating configuration questionnaires*

As a result of the analysis conducted on Phase 1a, the questionnaire was revised slightly for Phase 1b. The revised version of the questionnaire administered in Phase 1b after the hatch had been operated on the first occasion is included in Appendix 6. In the revised questionnaire, volunteers were also asked to indicate whether the exit was lighter, the same weight or heavier than they had expected it to be; whether they had operated it in the manner shown on the safety card and how long they thought it had taken them to open the exit.

As all the volunteers in Phase 1b operated the exit three times, a shortened version of the questionnaire was completed by the volunteers after the second and third times that they operated the exit (Appendices 7 and 8). In the shortened version of the questionnaire volunteers were asked to indicate the nature of any difficulties that they had experienced in operating the exit and were asked if examining the exit after the first and second tests had affected the manner in which they had subsequently operated the exit. Volunteers also assessed (using a seven point scale) the ease with which they had managed to operate the hatch, whether they had operated it in the manner indicated on the safety card and how long they thought it had taken them to open the exit.

2.4 Volunteers

A total of 192 volunteers took part in the two phases of the study, 96 in each phase of the study. Exactly half of the volunteers in each phase were male and half female. The volunteers were recruited by local advertising to take part in individual tests aboard the cabin mock-up. In order for the volunteers to be representative of the smallest 50th percentile of the population, that is, those who could be expected to encounter most difficulties in completing the task, the maximum height and weight of volunteers recruited for these tests were the criteria for 50th percentile US males and females (Ref. 9) as indicated in Table 2.

Table 2 Fiftieth percentile height and weight for males and females

	50th Percentile Height	*50th Percentile Weight*
Males	174cm	74kg
Females	163cm	61kg

Volunteers were recruited who were within both the height and weight criteria but strict enforcement of both these criteria could result in only volunteers who were considerably less than the 50th percentile requirement being recruited. Consequently, some volunteers were recruited who were marginally over on the height criterion, providing their weight was well under the weight criterion for the study (and vice versa).

2.5 Procedure

In both phases of the study, each volunteer was randomly assigned to one of the experimental conditions on arrival at Cranfield. A member of the research team, trained and dressed as a cabin attendant, briefed each volunteer about the nature of the test. (Appendix 9 contains the pre-test briefing for Phase 1a and 1b.) In order to maximise realism, the volunteers were not briefed about the precise nature of the test but were told that they would be required to lift a weight equivalent to that of a heavy suitcase (potential volunteers with back problems were screened out during recruitment). There was some concern about the possibility of the tests causing physical injury as some of the volunteers could be required to lift weights which were in excess of the recommended maximum lifting capacity for their physical build (Ref. 8). In order to minimise the possibility of any injury, in the pre-test briefing each volunteer was asked to exercise caution during the test.

During the briefing, each volunteer was weighed and measured by a member of the research team, and asked to complete a consent form indicating that they understood the nature of the study and that they believed that they were physically able to take part in the test. Each volunteer was then given a numbered vest, indicating the experimental condition to which he or she had been assigned, and escorted to the cabin mock-up.

In the experimental conditions in which there was no dummy present the volunteer was sat in the seat adjacent to the Type III hatch. In the experimental conditions in which the dummy was present the dummy was positioned, with the seat belt

fastened, in the seat adjacent to the Type III hatch and the volunteer was seated next to the dummy. A fireman trained in First Aid (present for precautionary reasons) was seated in the aisle seat in the row immediately behind the volunteer.

Once seated inside the cabin, the volunteer was then given a safety briefing by a member of the research team trained and dressed as a cabin attendant. The safety briefing (see Appendix 10) included a demonstration of the method of operation of the oxygen mask, the floor proximity lighting and the location of the Type III hatch.

The cabin attendant then checked that the volunteer had fastened his or her seat belt. The volunteer heard the taped sound of engine noise and the cabin attendant then gave the volunteer an additional briefing (as recommended by NTAOCH 5/90, Ref. 3). In this briefing the volunteers' attention was drawn to the fact that as they were seated next to the overwing exit, they should note the operating instructions illustrated on the safety placard on the back of the seat in front of them. The sound of engine noise continued for approximately one minute before giving way abruptly to silence. Each volunteer was then given the instruction to 'Open the exit and get out'. If the volunteers were hesitant in moving towards the hatch (that is, if they had not begun to open the hatch after five seconds) the cabin attendant shouted the instruction 'Overwing exit' in order to hurry the volunteer. The test continued until the volunteer had successfully opened and disposed of the hatch, and evacuated through the exit onto the wing. If the volunteers experienced difficulty in opening, lifting or manoeuvring the hatch they were closely watched by the research team until they either successfully completed the task or gave up voluntarily. After the test was completed, each volunteer was asked to complete a short questionnaire in order to identify any problems that might have been experienced in carrying out the task.

2.5.1 *Phase 1a – pre-AN79 seating configuration*

On completion of the questionnaire (Appendix 5) each volunteer was then debriefed and thanked for taking part in the test before being paid an attendance fee.

2.5.2 *Phase 1b – AN79 seating configuration*

On completion of the first questionnaire (Appendix 6) each volunteer was reminded that they would be repeating the task twice more. They were then asked to examine the hatch (which had been placed on the seat in the exit row by a member of the research team), safety card or placard instructions or any other items which they considered might help them to operate the hatch. When the volunteer was ready to continue, the hatch was replaced by a member of the research team and the volunteer was asked to take the same seat as for the previous test and to fasten the seat belt.

The test procedure was then repeated twice more with the volunteer being given the safety briefing and the additional briefing (as recommended by NTAOCH 5/90, Ref. 3) on both occasions before operating the exit and completing a modified questionnaire (Appendices 7 and 8). Volunteers were not given any feedback regarding the accuracy of their performance during the tests. After completion of the third questionnaire (Appendix 8) the volunteer was then debriefed and thanked for taking part in the test before being paid an attendance fee.

3 RESULTS

3.1 Individual characteristics of the volunteers

3.1.1 *Phase 1a – pre-AN79 seating configuration*

The mean age of all the volunteers was 33.2 years, 32 years for males (with ages ranging between 21 and 49 years) and 34.4 years for females with ages ranging between 19 and 54 years). The male volunteers had a mean height of 169.5cm and a mean weight of 65.8kg. The mean height and weight for the female volunteers were 158.8cm and 54.5kg respectively. The median frequency of exercise for both males and females was once or twice a week. All but one of the volunteers (99.0%) had previously flown on a passenger aircraft and the mean category on the questionnaire for frequency of travel for the volunteers was 11–15 return journeys. There were no significant differences for age, height, weight or frequency of air travel or exercise (within the sexes) between the experimental conditions.

3.1.2 *Phase 1b – AN79 seating configuration*

The mean age of all the volunteers was 32.2 years, 31.5 years for males and 32.9 years for females. The age range for both sexes was between 20 and 49 years. The male volunteers had a mean height of 170.3cm and a mean weight of 65.2kg. The mean height for the female volunteers was 158.3cm with the mean weight being 55.5kg. The median frequency of exercise for both males and females was once or twice a week. Eight volunteers (8.3%) had not flown before. The median frequency of air travel for males and females was 6–10 return journeys. There were no significant differences for age, height, weight, frequency of air travel or exercise (within the sexes) between the experimental conditions.

3.2 The operation of the Type III hatch

In the analysis of the video tapes, for both Phase 1a and 1b, the starting point for recording how long each volunteer took to open the hatch and evacuate onto the wing was taken from the point when they put their hand on the hatch handle and so did not include any delay on the part of the volunteer in reacting to the simulated emergency situation. The volunteer was considered to have evacuated from the cabin when he or she had one foot on the wing outside.

The mean times for each condition with the dummy present for Phase 1a and Test 1 of Phase 1b are shown in Figures 5 and 6 in Appendix 11 and the mean time for each condition without the dummy present are shown in Figures 7 and 8 in Appendix 12. Appendix 13 contains the raw data giving demographic details for each volunteer, times taken by each volunteer to operate the Type III hatch and the length of time taken by each volunteer to lift and move the dummy.

Seventeen (17.9%) of the volunteers in the pre-AN79 seating configuration and two (2.1%) in Test 1 of the AN79 seating configuration, all female, were unable to complete the task of opening the hatch and evacuating onto the wing. These volunteers were assigned the same time for completing the task as that taken by the slowest volunteer who successfully completed the task. The mean times for all volunteers to complete the task were 38.0 seconds with a standard deviation of 38.6 seconds and 17.2 seconds with a standard deviation of 11.4 seconds for the pre-AN79 and AN79 seating configurations respectively. Appendix 13 shows that

individual mean times ranged between 11.4 and 87.6 seconds for the pre-AN79 seating configuration and between 4.7 and 51.1 seconds for the AN79 seating configuration.

Table 3 gives the mean times for volunteers in each experimental condition in the pre-AN79 seating configuration and Test 1 of the AN79 seating configuration to open the hatch and evacuate onto the wing. These times exclude the mean reaction times for volunteers of 3.9 seconds in the pre-AN79 and 4.8 seconds in the AN79 seating configuration as they unfastened their seat belt prior to putting their hand on the hatch handle or the times spent moving the dummy prior to, or during, operation of the hatch.

It can be seen from Table 3 that the mean times for each experimental condition ranged from 7.7 seconds for males operating the 12.5kg hatch in the condition without the dummy present in the AN79 seating configuration to 87.6 seconds for females operating the 15kg hatch in the condition with the dummy present in the pre-AN79 seating configuration. The mean time of 38.0 seconds for all volunteers in the pre-AN79 seating configuration was significantly slower than the time of 17.2 seconds for the AN79 configuration ($t_{111.43,\ 192} = 5.06$, $p<.001$[1]).[1]

Table 3 Mean times (in seconds) taken by volunteers in the pre-AN79 and Test 1 of the AN79 seating configuration to operate the hatch and evacuate onto the wing (standard deviations are shown in parentheses)

	Phase 1a – Pre-AN79				*Phase 1b – AN79 – Test 1*			
Hatch weight (kg)	*Dummy present*		*No Dummy present*		*Dummy present*		*No Dummy present*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
12.5	20.49	65.29	11.35	17.08	12.86	21.97	7.66	11.53
	(12.28)	(46.30)	(4.03)	(4.73)	(4.52)	(13.33)	(2.43)	(3.22)
15.0	15.05	87.57	13.87	26.56	13.12	29.61	12.88	13.33
	(7.89)	(42.59)	(8.61)	(16.18)	(4.33)	(16.85)	(7.72)	(6.26)
25.0	25.60	76.25	15.91	80.65	21.95	31.87	9.96	19.63
	(13.64)	(43.52)	(7.14)	(48.19)	(11.48)	(14.11)	(2.10)	(7.12)

NB times do not include time taken by volunteers in moving the dummy prior to, and during, operation of the hatch

[1] The t-test is used to establish whether any statistically significant differences exist between the sample means of the data obtained from two conditions. Whether the 't' value is sufficiently large to achieve significance will be influenced by the differences between the means, the variability in the data and also the number of cases per condition. The accompanying 'p' value refers to the means by which we decide whether observed differences reflect true differences or arose because of sampling error. In the text, the 'p' value indicates the likelihood of the observed value being due to chance factors rather than a genuine difference between groups.

In the AN79 seating configuration, two of the males operating the 15kg hatch in the condition without the dummy present jammed the hatch between the hatchframe and the seat and a third opened the exit prior to managing to unfasten his seat belt which caused some delay. These problems explain why the times for the 15kg hatch were longer than for the 25kg hatch.

Participants in the AN79 seating configuration were asked whether they thought the hatch was lighter, the same weight or heavier than they had expected it to be. Interestingly, 29.1% of those operating the 12.5kg hatch thought the hatch was heavier than they had expected it to be compared with 28.1% and 65.6% of those operating the 15kg and 25kg hatches respectively.

The following analysis examines the influence of hatch weight in the alternate seating configurations examined in Phases 1a and 1b in the conditions with the dummy obstructing the exit. The influence of the same factors is then examined in the conditions without the dummy present. Finally, the effects of learning in the conditions with and without the dummy present, as measured by the three tests conducted in Phase 1b (the AN79 seating configuration), will be assessed.

3.3 Influence of hatch weight and seating configuration on the operation of the Type III hatch in the conditions with a dummy present

An analysis of variance test for independent groups was conducted on the times taken by volunteers to operate the hatch and evacuate onto the wing in the conditions with the dummy present in order to determine the possible influence of reducing the weight of the hatch and changes to the seating configuration (see Appendix 11). Significant main effects were observed for the seating configuration and the sex of the volunteer. Increasing the space between the seats from the pre-AN79 to the AN79 seating configuration led to significantly faster operation times for volunteers ($F^2_{1,191} = 28.51$, $p<.001$) and these times were faster for all three weights of hatch although the effect was greater for females than males. Female volunteers were significantly slower than males ($F_{1,191} = 46.78$, $p<.001$). Reducing the weight of the hatch ($F_{2,191,} = 1.100$, NS) did not significantly reduce the times taken by the volunteers in the pre-AN79 configuration in the conditions with the dummy present. However, a significant difference was observed in the AN79 seating configuration between the times taken to operate a 12.5kg and a 25kg hatch ($t_{30,32} = 2.21$, $p<.05$). These results indicate that a reduction in hatch weight from 25kg to 12.5kg is necessary in addition to an increase in seat space from the pre-AN79 to the AN79 seating configuration in order to significantly reduce the times taken to operate the hatch with a dummy representing an incapacitated passenger obstructing the exit.

3.3.1 *Two-way Interaction effects*

A significant two-way interaction was also observed (see Appendix 11) between the seating configuration and the sex of the volunteer in the conditions with the dummy present ($F_{1,191} = 19.82$, $p<.001$). The interaction indicated that when the seat pitch was increased from the pre-AN79 to the AN79 seating configuration, the reduction in operation times was significantly greater for female than male volunteers.[2]

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[2] The F ratio is obtained by performing the technique of Analysis of Variance in order to establish whether any statistically significant differences exist between the data from a number of conditions. Whether the F ratio is sufficiently large to achieve significance will be influenced by the variability in the data and also by the number of conditions and replications of the test.

3.4 Influence of hatch weight and seating configuration on the operation of the Type III hatch in the conditions without a dummy present

An analysis of variance test was also conducted on the times taken by volunteers to operate the hatch and evacuate onto the wing in the conditions without the dummy present (refer to Appendix 12). Significant main effects were observed for the weight of the hatch, the seating configuration and the sex of the volunteer. Reductions in the weight of the hatch ($F_{2,191,} = 13.81$, $p<.001$) significantly reduced the times taken by the volunteers in the conditions without the dummy present. Exit operation times in the AN79 seating configuration were significantly faster for both the 12.5kg and 25kg hatch than in the pre-AN79 seating configuration. Although, the operation times for the 15kg hatch were faster in the AN79 than in the pre-AN79 seating configuration, the differences were not significant. Increasing the space between the seats from the pre-AN79 to the AN79 seating configuration led to significantly faster times for volunteers ($F_{1,191} = 22.42$, $p<.001$). Female volunteers were significantly slower than males ($F_{1,191} = 25.87$, $p<.001$).

3.4.1 *Three-way Interaction effects*

A significant three-way interaction can also be observed in Appendix 12 between the weight of the hatch, seating configuration and the sex of the volunteer ($F_{2,191} = 6.54$, $p<.01$) in the conditions without the dummy present. Increasing the seat space from the pre-AN79 seating configuration to the AN79 seating configuration led to a greater reduction in the times taken to operate the hatch and the females benefited to a greater extent than males from the increased space between the seats. Due to the increased space between the seats, greater reductions in weight were required in the AN79 (from 25kg to 12.5kg) than in the pre-AN79 seating configuration (from 25kg to 15kg) in order for significantly faster exit operation times to be achieved.

3.5 The influence of practice on the operation of the Type III hatch in an AN79 seating configuration, Tests 2 and 3

Test 2

Two volunteers (2.1%), one male and one female, were unable to open the hatch and evacuate onto the wing during the second test. The mean time for all the volunteers in Test 2 was 14.7 seconds with a standard deviation of 12.4 seconds. It can be seen from Appendix 13 that individual times for volunteers in Test 2 ranged from 3.9 seconds to 51.7 seconds.

Test 3

One female volunteer (1%) was unable to open the hatch and evacuate onto the wing during the third test. The mean time for all volunteers to complete the test was 12.9 seconds with a standard deviation of 12.2 seconds. Appendix 13 indicates that individual times ranged from 3.8 seconds to 62.4 seconds.

Table 4 gives the mean times for volunteers in Tests 2 and 3 which are also shown in Appendices 15 and 16 respectively.

Table 4 Mean times (in seconds) taken by volunteers in each experimental condition to operate the hatch and evacuate onto the wing in Tests 2 and 3 of the AN79 seating configuration (standard deviations are shown in parentheses)

	Test 2				*Test 3*			
Hatch weight (kg)	*Dummy present*		*No Dummy present*		*Dummy present*		*No Dummy present*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
12.5	9.11	20.61	6.17	8.88	7.98	14.35	6.23	14.85
	(5.44)	(13.63)	(3.14)	(5.12)	(5.03)	(11.56)	(1.95)	(19.29)
15.0	14.49	23.85	7.52	14.11	13.10	18.35	5.96	11.81
	(15.15)	(11.43)	(3.08)	(13.41)	(14.46)	(12.54)	(2.19)	(9.03)
25.0	19.76	25.69	7.36	18.32	13.96	21.99	7.30	19.02
	(16.63)	(17.20)	(4.19)	(9.87)	(7.74)	(17.51)	(1.49)	(17.89)

NB times do not include time taken by volunteers in moving the dummy prior to, and during, operation of the hatch

Table 4 shows that the mean times for each experimental condition for Test 2 ranged from 6.17 seconds for males operating the 12.5kg hatch in the condition without the dummy present to 25.69 seconds for females operating the 25kg hatch in the condition with the dummy present. It can also be seen from Table 4 that the mean times for each experimental condition in Test 3 ranged from 5.96 seconds for males operating the 15kg hatch in the condition without the dummy to 21.99 seconds for females operating the 25kg hatch in the condition with the dummy present.

3.6 The influence of practice, hatch weight and sex of the volunteer in the conditions with the dummy present on the operation of the Type III hatch in an AN79 seating configuration

A repeated measures analysis of variance test was then conducted on the data obtained from the conditions with the dummy present in all three tests in order to investigate the influence of practice. The mean times for all three tests are tabulated in Appendix 17 together with the detailed results of the effects of practice. The times for the three tests are illustrated in Appendix 18. Table 5 summarises the results of this analysis.

Table 5 Analysis of variance summary table indicating effects of practice, hatch weight and the sex of the volunteer on the operation of the Type III hatch in the presence of the dummy

	Sum of Squares	*Degrees of Freedom*	*Mean Square*	*F*	*Signif. of F.*
Within cells	9084.89	84	108.15		
Practice	1164.26	2	582.13	5.38	.006
Sex by practice	168.46	2	84.23	.78	.462
Hatch weight by practice	49.83	4	12.46	.12	.977
Sex by hatch weight by practice	174.80	4	43.70	.40	.805

It can be seen from Table 5 that there was a significant practice effect across the three tests ($F_{2,47} = 5.38$, $p<.01$) indicating that the mean times to operate the Type III hatch in the conditions with the dummy present were reduced by practising the task three times. Analysis of the hatch operation times indicated that practice helped males in the 12.5kg and 25kg hatch conditions and the females operating all three weights of hatch. The apparent failure of males operating the 15kg hatch in these tests to benefit from the practice is due to a higher percentage of males in this hatch condition jamming the hatch in the hatchframe or between the hatch and the seat.

An analysis of variance test for independent groups conducted on the times taken by volunteers after three tests in the conditions with a dummy present indicated that there were no significant influences due to hatch weight ($F_{2,47} = 1.30$, NS) or the sex of the volunteer ($F_{1,47} = 3.47$, NS).

3.7 The influence of practice, hatch weight and sex of the volunteer in the conditions without the dummy present on the operation of the Type III hatch in an AN79 seating configuration

A repeated measures analysis of variance test was also conducted on the data obtained from all three tests in the conditions without a dummy present in order to investigate the influence of practice. (The times for the three tests are tabulated in Appendix 19 and illustrated in Appendix 20.) The results of this analysis are summarised in Table 6 which shows that there was no significant practice effect across the three tests ($F_{2,47} = 1.26$, NS).

Table 6 Analysis of variance summary table indicating effects of practice, hatch weight and the sex of the volunteer on the operation of the Type III hatch in the conditions without the dummy present

	Sum of Squares	*Degrees of Freedom*	*Mean Square*	*F*	*Signif. of F.*
Within cells	3900.49	84	46.43		
Practice	117.40	2	58.70	1.26	.288
Sex by practice	99.26	2	49.63	1.07	.348
Hatch weight by practice	136.91	4	34.23	.74	.569
Sex by hatch weight by practice	77.65	4	19.41	.42	.795

An analysis of variance test for independent groups conducted on the times taken by volunteers after three tests in the conditions without the dummy present indicated that there was no significant influence for reduction in hatch weight after three tests ($F_{2,47} = 0.57$, NS). However, the sex of the volunteer was a significant influence ($F_{1,47} = 6.99$, $p<.025$) with females taking longer than males after the third test.

3.8 Problems experienced by volunteers in operating the Type III hatch and the effects of practice

In the pre-AN79 seating configuration, just over half the volunteers (52%) considered that they had been impeded in their access to the exit, 43.8% of these by the dummy and 5.2% by the seat adjacent to the exit. In addition, 47.9% of the volunteers considered that they were impeded in their operation of the hatch, 10.4% by the seat adjacent to the hatch, 10.4% by lack of space, 7.3% by the dummy and 5.2% by the weight of the hatch. The percentage of volunteers in the AN79 seating configuration tests who reported that they had experienced some difficulties in operating the hatch reduced from 66.7% in Test 1 to 53.1% in Test 2 and to 43.8% in Test 3. The difficulties experienced by the volunteers during the three tests are shown in Table 7.

Some of the problems experienced by the volunteers, such as interpretation of instructions or hitting themselves with the hatch (usually on the head), were reduced or removed completely as a result of practice. Six per cent of those in Test 1 who had difficulty in interpreting the hatch operating instructions were unsure whether the hatch opened inwards or outwards.

Table 7 Problems experienced by volunteers in operating the Type III hatch during the three tests (figures indicate percentage of volunteers experiencing each difficulty)

Type of problem	*Percentage of Volunteers*
Test 1	
Dummy obstructed volunteer in some manner	52.1*
Hit head on hatch as pulled handle down	44.8
Thought hatch was hinged and would remain attached to fuselage	19.8
Hatch heavy and awkward to lift	16.7
Lack of space to manoeuvre the hatch	15.6
Experienced difficulty in interpreting the hatch operation instructions	12.5
Hatch became jammed between seat and hatchframe	7.3
Hatch became jammed in hatchframe	5.2
Did not know what to do with hatch once opened	4.2
Experienced difficulty in disposing of the hatch	2.1
Test 2	
Dummy obstructed volunteer in some manner	31.3*
Hatch heavy and awkward to lift	15.6
Hatch became jammed in hatchframe	12.5
Lack of space to manoeuvre the hatch	11.5
Hit head on hatch as pulled handle down	9.4
Hatch became jammed between seat and hatchframe	7.3
Hatch operation instructions not clear	1.0
Test 3	
Dummy obstructed volunteer in some manner	31.3*
Hatch heavy and awkward to lift	19.8
Hatch became jammed in hatchframe	5.2
Lack of space to manoeuvre the hatch	9.4
Hit head on hatch as pulled handle down	6.3
Hatch became jammed between seat and hatchframe	5.2

* percentage refers only to 48 volunteers in conditions with the dummy present

The frequency with which some of the problems identified occurred, such as lack of space, the weight or awkwardness of the hatch and jamming of the hatch in the hatchframe or between the hatchframe and the seat, were relatively unaffected by practice. In the second test, 4.2% of those who commented on the weight of the hatch found it awkward to manoeuvre and two volunteers (2.1%) were unable to lift the hatch to put it outside. In the case of one of these volunteers, a male operating a 15kg hatch, he was unable to free the hatch when it became jammed in the hatchframe. In Test 3, 6.3% of those who reported that the hatch was heavy found it awkward to manoeuvre.

Analysis was also conducted (using repeated measures anova) in order to identify volunteers' perceptions of the relative ease or difficulty with which they were able to manage the exit operation in terms of its size, weight and location in relation to their seat. Practising the task three times led to volunteers' perceiving the size of the exit ($F_{2,287} = 5.81$, $p<.01$) and also the weight of the exit ($F_{2,287} = 3.83$, $p<.025$) to be significantly more difficult to operate possibly due to fatigue as a result of performing the task three times in a short space of time. No significant effect was observed for their perceptions of the location of the exit in relation to the seat across the three tests ($F_{2,287} = .70$, NS).

3.9 Perceived benefits of practice and familiarity in operating the Type III hatch

When given the opportunity to examine the hatch, instructions or any other items which may assist them in operating the hatch, 41.1% of volunteers looked at the safety card or placard and 28.6% examined the top handle on the hatch. Thirty per cent examined the inside surface of the hatch and 22% examined the hatchframe or seat cushion immediately adjacent to the exit. Eleven per cent looked at the outside surface of the hatch and 10.4% examined the bottom handle of the hatch.

After Test 1, 17.7% of volunteers stated that examining the hatch or instructions had made them more familiar with knowing what they should do or what to expect. Two per cent of volunteers commented that it had enabled them to assess the weight of the hatch. Identification of a technique required to operate the hatch was reported by 12.5% of volunteers as a benefit of examining the hatch and 8.3% said that it enabled them to realise that they should put the hatch outside the cabin. In the conditions with the dummy present, 14.6% stated that examining the hatch helped them to identify how they could or should manoeuvre the hatch around the dummy.

After Test 2, 8.3% of volunteers stated that they felt more familiar with the task and knew what to expect after the practice with 2.1% reporting that it allowed them to assess the weight of the hatch. Identification of a technique to operate the hatch was again reported by 12.5% as a benefit of examining the hatch or instructions with 2.1% realising that the hatch should be placed outside the cabin. In the conditions with the dummy present, 10.4% stated that examining the hatch had helped them to identify how to manoeuvre the hatch around the dummy.

3.10 Placement of hatch

The hatch was placed outside the cabin by 63.5% of volunteers in the pre-AN79 seating configuration despite the pictorial instructions, (on the back of the row of seats which form the access route from the cabin aisle to the exit) which indicates that the hatch should be disposed of outside the cabin. In Test 1 of the AN79 seating

configuration, a much lower percentage (37.5%) of volunteers placed the hatch outside the cabin but this percentage increased in Tests 2 and 3 to 69.8% and 80.2% respectively. Table 8 shows where volunteers in Phase 1a and the three tests of Phase 1b placed the hatch.

3.10.1 *Phase 1a*

Table 8 shows that the majority of the volunteers in the pre-AN79 seating configuration (53.1%) disposed of the hatch (either inside or outside the cabin) before passing through the exit but 29.2% evacuated from the cabin prior to letting go of the hatch. One male volunteer left the hatch lying on top of the dummy and climbed out over the top of the hatch.

Table 8 Placement of hatch by volunteers in phase 1a and 1b (figures indicate percentage of volunteers placing hatch in each location)

	Pre-AN79	*AN79 Test 1*	*AN79 Test 2*	*AN79 Test 3*
Outside on the wing	63.5	37.5	69.8	80.2
On floor in exit row	2.1	53.1	25.0	16.7
On seat in exit row	10.4	7.3	4.2	2.1
In the aisle	4.2	–	–	–
On seat in row in front of exit	2.1	–	–	–
Failed to complete task	17.7	2.1	1.0	1.0

3.10.2 *Phase 1b – Test 1*

In Test 1 of the AN79 seating configuration, the majority of volunteers (74%) disposed of the hatch before exiting but 21.9% put the hatch down after exiting. Four volunteers (4.2%) did not dispose of the hatch: two were unable to open the hatch and as the other two moved the dummy the hatch fell in (on top of the dummy) allowing them to evacuate without actively disposing of the hatch. Eighty five per cent of all the volunteers in Test 1 left the hatch in a position, either inside or outside the cabin, which would have partly blocked the access to the exit or the escape route from the exit had there been any other passengers on board.

3.10.3 *Phase 1b – Test 2*

The majority of volunteers in Test 2 (67.7%) exited from the cabin after they had disposed of the hatch, 30.2% evacuated from the cabin before putting the hatch down and the remaining 2.1% failed to complete the task. In total, 79.2% of volunteers in Test 2 left the hatch in a position which blocked the access to the exit or the escape route outside the exit.

3.10.4 *Phase 1b – Test 3*

Most of the volunteers in Test 3 (65.6%) exited from the cabin after disposing of the hatch but 33.3% placed the hatch down after leaving the cabin. One volunteer (1%) failed to complete the task. The hatch was left in a position which partly blocked the access to, or the escape route from, the exit by 79.2% of volunteers in Test 3.

3.11 Influence of individual characteristics of the volunteers

Analysis (using correlations) was conducted in phase 1a (pre-AN79 seating configuration) in order to determine whether any individual characteristics of the volunteers significantly influenced the time taken to open the hatch and evacuate onto the wing. Included in this analysis were demographic details such as height, weight, age and physical fitness. Interestingly, individual characteristics such as height and weight of the volunteers (within the sexes), age and frequency of air travel were not significantly associated with the times taken by the volunteers to open the hatch and evacuate onto the wing. However, females who exercised more frequently were significantly faster ($r = .4048$, $p < .025$)[3] than those who exercised less frequently. As all but one of these factors was observed to have no significant influence in Phase 1a they were not analysed in Phase 1b.

3.12 Handedness of volunteers

The handedness of volunteers and the hand used to operate the top handle of the hatch was recorded in Phase 1a of the tests. Analysis indicated that the dominant hand tended to be used to operate the handle at the top of the door (correlation $r = .3217$, $p < .001$) but this did not significantly predict the time taken by volunteers to open and dispose of the hatch. As no significant effect was observed for handedness of volunteers in Phase 1a, this was not analysed in the tests conducted in Phase 1b.[3]

4 DISCUSSION

4.1 The operation of the Type III hatch

The mean times taken by the volunteers in the pre-AN79 seating configuration to open the hatch and evacuate onto the wing ranged between 11.35 seconds for males operating the 12.5kg hatch in the condition without the dummy present to 87.57 seconds for females operating the 15kg hatch in the condition with the dummy present. Mean times for Test 1 of the AN79 seating configuration ranged from 7.66 seconds for males operating the 12.5kg hatch in the condition without the dummy present to 31.87 seconds for females operating the 25kg hatch in the condition with the dummy present.

The addition of volunteers' reaction times to account for the time between the instruction to 'Open the exit and get out' and the time when they placed their hand on the hatch handle would increase overall times for volunteers by a mean of 3.91 seconds for the pre-AN79 and 4.75 seconds for the AN79 seating configuration. The slightly faster reaction time recorded in the pre-AN79 seating configuration may be partly due to the tighter seat pitch.

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[3] The 'r' value is obtained when using correlations and indicates the strength of the concomitant variation of paired measures.

The volunteers were not briefed as to the nature of the test prior to taking part and so the experimental situation simulated the ambiguity which may occur in an emergency in which passengers may not be given any instructions. However, some participants may have studied the safety card and/or safety placards more thoroughly than they would in flight and they knew that they were in a test situation. This may have led to increased awareness on the part of the volunteers and should not be taken to indicate that all passengers would be equally prepared in an aircraft emergency. In addition, in the event of an incapacitated passenger obstructing the Type III exit in an emergency, longer delays in operating the hatch and evacuating other passengers may result, for example, due to the need for the careful removal of the hatch to avoid injury to the passenger, or removal of the passenger to eliminate obstructions from the exit seat row.

An interesting comparison can be made between the times of the volunteers who were unaware of the precise nature of the task which they were required to undertake and those of a specifically trained person who was fully aware of the nature of the task. A trained person (a male Cranfield staff member within the 50th percentile height and weight criteria) opened each weight of hatch, with the seating arranged in a pre-AN79 seating configuration, a total of five times with and without the dummy present. The mean times for the trained person to open the hatch and evacuate onto the wing (from the end of the instruction to 'Open the exit and get out') ranged from 3.2 seconds for the 12.5kg hatch in the no dummy condition to 7.6 seconds for the 25kg hatch in the dummy conditions. As the timing of the task differed slightly and the trained person had prior knowledge of the nature of the task, direct comparisons with the times taken by the volunteers would not be valid. However, the mean times indicate that it is possible for a trained person who is fully aware of the nature of the task, and prepared for it, to open the hatch and evacuate onto the wing in less than 8 seconds even when faced with an incapacitated passenger obstructing the exit.

4.2 The influence of hatch weight, seating configuration, the presence of the dummy and the sex of the volunteer on the operation of the Type III hatch

Reductions in the weight of the Type III hatch, increasing the seat space available from the pre-AN79 to the AN79 seating configuration and the absence of the dummy all led to significantly shorter hatch operation times. The influence of increasing the seat space available was of significantly greater benefit for females than for males.

In the conditions with the dummy present, increasing the seat space between the seats from the pre-AN79 to the AN79 seating configuration led to significantly faster operation times for volunteers operating all three weights of hatch. Reducing the weight of the hatch did not significantly reduce the times taken by volunteers in the pre-AN79 seating configuration, although when the seat space available was increased to the AN79 requirement and the weight of the hatch was reduced from 25kg to 12.5kg a significant reduction was achieved in the operation times for females.

In the conditions without the dummy present, reductions in the weight of the hatch and an increase in the seating configuration from pre-AN79 to AN79 significantly reduced the times taken by the volunteers for both the 12.5kg and 25kg hatch. Although operation times were faster for the 15kg hatch in the AN79 than in the pre-AN79 seating configuration the differences were not significant, possibly due to

some of the volunteers in this condition jamming the hatch in the hatchframe, or between the hatchframe and the seat (as described in Section 3.4). A significant interaction indicated that the effect of reducing the weight of the hatch from 25kg to 12.5kg and increasing the seat space from the pre-AN79 to the AN79 seating configuration led to a greater reduction in the times taken for females to operate the hatch than for males.

The results of the tests with and without the dummy present indicate that a reduction in hatch weight from 25kg to 12.5kg is necessary in addition to an increase in seat space from the pre-AN79 to the AN79 seating configuration in order to significantly reduce the times taken to operate the hatch and that the benefits will be significantly greater for females than for males. The benefit of reductions in operation times were not achieved by increasing the space between the seats from the pre-AN79 to the AN79 seating configuration without also reducing the weight of the hatch. It is only through a combination of increasing the seating space available to the AN79 seating configuration and reducing the hatch weight from 25kg to 12.5kg that significant reductions in the delay that might occur before the exit would become operable in an emergency could be expected. In view of the times taken by the volunteers to operate the hatch, the results support the opinions expressed (Ref. 3) and indicate that both a reduction in hatch weight and an increase in seat space are necessary for significant improvements in the operation of Type III exits by passengers to be achieved.

The presence of the dummy led to considerable variation in volunteers' behaviour. In the pre-AN79 seating configuration, 37.5% of volunteers in the conditions with the dummy present attempted to move the dummy prior to, or during, the operation of the Type III hatch to facilitate completion of the task. In the AN79 seating configuration, 27.1% attempted to move the dummy to facilitate completion of the task, suggesting that the task was perceived by volunteers to be easier to perform with the increased seat space available in this configuration. Some volunteers attempted to open the hatch more carefully so as not to 'injure' the dummy passenger whereas others appeared to have little regard for the possibility of 'injury' to the dummy passenger. The dummy which was representative of a 50th percentile male was extremely heavy to move and caused more of an obstruction to the female volunteers than to the males.

4.3 The influence of practice on the operation of the Type III hatch in an AN79 seating configuration

Practising the task three times significantly reduced the times taken by the volunteers in an AN79 seating configuration to operate the hatch and evacuate onto the wing in the conditions with the dummy present. No significant reduction was observed in the times between the first and second tests. After practising the task three times neither the weight of the hatch nor the sex of the volunteer significantly influenced the time taken by volunteers to operate the hatch and evacuate onto the wing in the conditions with the dummy present.

In the conditions without the dummy present, no significant practice effect was observed. The mean time for Test 1 was longer than that for Test 2 but fell just short of significance, possibly due to the small sample size. After practising the task three times, no significant influence was observed for hatch weight although the sex of the volunteer remained a significant influence with females taking longer than males.

No significant interaction effects were observed between practice, the weight of the hatch or sex of the volunteer in the AN79 seating configuration either with or without the dummy present.

The results of practising the task three times indicate that it would be beneficial to seat a trained rather than an untrained person in the seat immediately adjacent to the Type III exit even with a 12.5kg hatch.

4.4 Problems experienced by volunteers in operating the Type III hatch and the effects of practice

The lack of space between the seat rows by the Type III hatch, and between the seat adjacent to the hatch and the hatch itself, exacerbated the problems experienced by the volunteers in the pre-AN79 seating configuration and disguised the possible influence of reducing hatch weight, particularly in the conditions with the dummy present.

In the AN79 seating configurations, some of the difficulties experienced by the volunteers reduced in frequency or were removed completely as a result of the practice. The percentage of volunteers who hit their head as they operated the hatch reduced considerably and the problems of interpreting the instructions were almost completely removed after the first test. However, practice was not perceived by the volunteers as helping to overcome the lack of space in which to manoeuvre the hatch. Similarly, the tendency for some volunteers to jam the hatch either in the hatchframe or between the seat and the hatchframe was only slightly reduced by practice although this may be confounded by a tendency for some volunteers to rush at the task as they tried to open the hatch more quickly than in the previous test. Practice also did not appear to help some volunteers to manage the weight of the hatch and some volunteers appeared to suffer from fatigue due to performing the task three times in a few minutes.

4.4.1 *Perceived benefits of practice and familiarity in operating the Type III hatch*

Volunteers' perceptions of the benefits of practice (refer to Appendices 17 to 20) indicated that they knew what to expect in terms of the correct method of operation and what they were required to do. One important benefit of the practice was that volunteers became aware that a particular technique was required in order to open the hatch and manoeuvre it in the limited space available and that practice gave them the opportunity to familiarise themselves with, and develop, the necessary technique. Handling the hatch facilitated in determining the appropriate technique for handling the particular weight of hatch.

The opportunity for practice also enabled volunteers to learn an effective technique for operating and handling the exit when an obstruction was present although in the case of the conditions with the dummy present this learning is likely to be very situation specific. Interestingly, volunteers' subjective assessments of the ease of the weight and size of the exit in managing the task indicated that they found these aspects of the task more difficult and not easier with practice possibly, partly due to the fatigue effect described in Section 4.4.

4.5 Placement of hatch and clarity of Type III hatch operating instructions

Although the safety card illustrations showed the hatch being pushed outside the cabin through the exit the meaning of these instructions was not correctly interpreted by all the volunteers. (This is discussed further in Section 4.6). A higher percentage (63.5%) of those in the pre-AN79 than those in Test 1 of the AN79 seating configuration (37.5%) placed the hatch outside the cabin. More than half of the volunteers (53.1%) in Test 1 of the AN79 seating configuration left the hatch on the floor in the exit row compared to only 2.1% in the pre-AN79 seating configuration. This suggests that one consequence of increasing the seat space in the row immediately adjacent to the Type III hatch is to give passengers the space to drop the hatch on the floor as they evacuate rather than to dispose of it outside the cabin as indicated on the safety card.

To prevent passengers from leaving the hatch on the floor it may be beneficial to clarify the hatch operating instructions already provided, on the safety placard and safety card, in order to ensure that the correct method of disposing of the hatch is obvious to passengers. Practising the task three times increased the percentage of volunteers who placed the hatch outside the cabin in Test 2 (69.8%) and Test 3 (80.2%) and also reduced the percentage of volunteers who left the hatch blocking the access to the exit either on the seat, or the floor, in the exit row although it had little influence on the percentage who left the hatch in a position which would obstruct the exit.

The safety placard on the back of each of the seats forming the access to the exit shows a (female) person standing in an unrestricted area facing the hatch and pulling the top handle down with her right hand (Appendix 4). The second illustration shows the female holding the removed hatch in both hands which may imply to the passenger that the hatch is lightweight and easy to operate. The final illustration shows the female pushing the hatch through the exit aperture. The action of operating the hatch appears to be performed with relative ease and the seats are illustrated in a manner which suggests that they are not causing any obstruction to the operation of the hatch.

Analysis of the pre-AN79 seating configuration data indicated that although the safety placard illustrated the hatch being disposed of through the open exit, 15.6% of the volunteers interpreted this illustration as indicating that the hatch was hinged and stated that it was not clear that the hatch had to be lifted out in order to be removed. This may explain why 10.4% of the volunteers in the pre-AN79 seating configuration considered that the placard did not clearly indicate where the hatch should be placed after it had been removed and why they did not know what to do with the hatch after they had removed it from the fuselage. Similar results were observed in the AN79 seating configuration with 21.8% of volunteers expecting that the hatch would be hinged.

As the illustrations on the safety card and seat back placards showed a standing person opening the hatch this is likely to explain why almost all of the volunteers in both Phase 1a and 1b opened the hatch in this manner. Although, 96.9% of the volunteers in the pre-AN79 seating configuration stood up, this percentage reduced slightly in each of the AN79 tests with 90.6%, 92.7% and 91.7% standing up to operate the hatch in Tests 1, 2 and 3 respectively.

One problem that was not clear from the safety card or the placard was that the top handle of the hatch operated easily and resulted in the hatch falling inward on top of a number of volunteers. As a result, 35.4% of the volunteers in the pre-AN79 seating configuration received a blow on the head, caused by the hatch as it fell inwards. In the case of two of the volunteers, the blow was severe and caused some distress. Similar results were also observed in the tests conducted in the AN79 seating configuration with 44.8% hitting their head as they operated the hatch in Test 1. However, this reduced to 9.4% and 6.3% in Tests 2 and 3 respectively.

Given the seating arrangement in these tests in which the seat cushion was projecting further than the centre line of the exit, it may have been easier for the volunteers in the no dummy conditions (who were seated in the seat immediately adjacent to the hatch) to operate the hatch whilst seated. Remaining seated may be an easier position for passengers to adopt if they are to open the hatch more easily as the space in which to manoeuvre the hatch is maximised. The trained person (referred to in Section 4.1) opened the hatch whilst seated. However, any advantage of operating the hatch whilst seated as opposed to in a standing position is likely to depend on the seat pitch in the row adjacent to the Type III hatch. It may be possible to operate the hatch whilst seated in the pre-AN79 seat pitch or in the AN79 seat pitch (Ref.1, paragraph 4.1.1). Alternatively, if the outboard seat is removed (Ref. 1 paragraph 4.1.2) it is not practicable to remain seated whilst operating the hatch.

4.6 Influence of individual characteristics of the volunteers on the ease of operation of the Type III hatch

As females who exercised more frequently were significantly faster than those who reported that they exercised infrequently, this suggests the importance of seating a physically fit person immediately adjacent to the exit. However, the lack of any significant relationships in the tests conducted in the pre-AN79 seating configuration between the height, weight and age of the volunteer suggests that the 50th percentile range may not necessarily represent a worst case situation. It would appear that the worst case situation may be more specific to the sex of the volunteers rather than their age, height, weight or physical fitness. Interestingly, a number of the volunteers were able to open the hatch and to shoulder its weight, whereas taller volunteers would have been required to bend down in order to lift the hatch. In addition, taller or heavier volunteers would have considerably reduced the space available in the exit row, possibly making it more difficult to open and dispose of the hatch.

4.7 Handedness of volunteer

The lack of any significant relationship between the handedness of the volunteer and operation time may be partly explained by the need to pull the hatch inwards before ejecting it through the exit. If the dominant hand is used at the top of the hatch, the weaker hand is then left to take the weight of the hatch. Unless the hatch is rotated in the available space (an action carried out by a few volunteers) the weaker hand is required to support the weight of the hatch and take the lead in the action of ejecting the hatch through the exit.

5 CONCLUSIONS

1 The time taken to operate the hatch and make the exit available was significantly decreased by both a reduction in the weight of the hatch from 25kg to 12.5kg and the increase in the available seat space given by the change from the pre-AN79 to the AN79 requirement.

2 In most cases, volunteers in the AN79 seating configuration were significantly faster at operating the Type III hatch and evacuating onto the wing than those in the pre-AN79 seating configuration. No significant differences were found for males operating the 15kg and 25kg hatches.

3 The combined benefits of reduction in hatch weight and increase in seat space available from the pre-AN79 to the AN79 seating configuration would be significantly greater for females than for males.

4 The presence of the dummy increased the time to make the exit available to a significantly greater extent in the pre-AN79 seating configuration than in the AN79 configuration. This demonstrates the effect an incapacitated person could have on an evacuation of this type and hence the need to incorporate such considerations into the design of simulation exercises such as that described in this report.

5 Providing volunteers with the opportunity to practise the task three times led to a significant reduction in the times taken to operate the Type III hatch and evacuate onto the wing in conditions with the dummy present. However, no such effect was found without the dummy.

6 Practice provided an opportunity for volunteers to develop an effective technique for opening and manoeuvring the hatch in the limited space available inside the cabin and also reduced the likelihood of misinterpretation of instructions.

7 The times taken by the trained person are a strong indication of the advantage of seating a trained person in the seat adjacent to the Type III exit.

8 The problems experienced by the volunteers over the interpretation of the hatch operating instructions indicated that the correct method of disposing of the hatch is not clearly conveyed to the untrained passenger on the safety card (or placard). Safety cards and placards could be designed in a manner which clearly indicates to the untrained passenger that the Type III hatch is heavy and that it is not attached to the aircraft in the same manner as the main exits.

6 REFERENCES

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Appendix 1

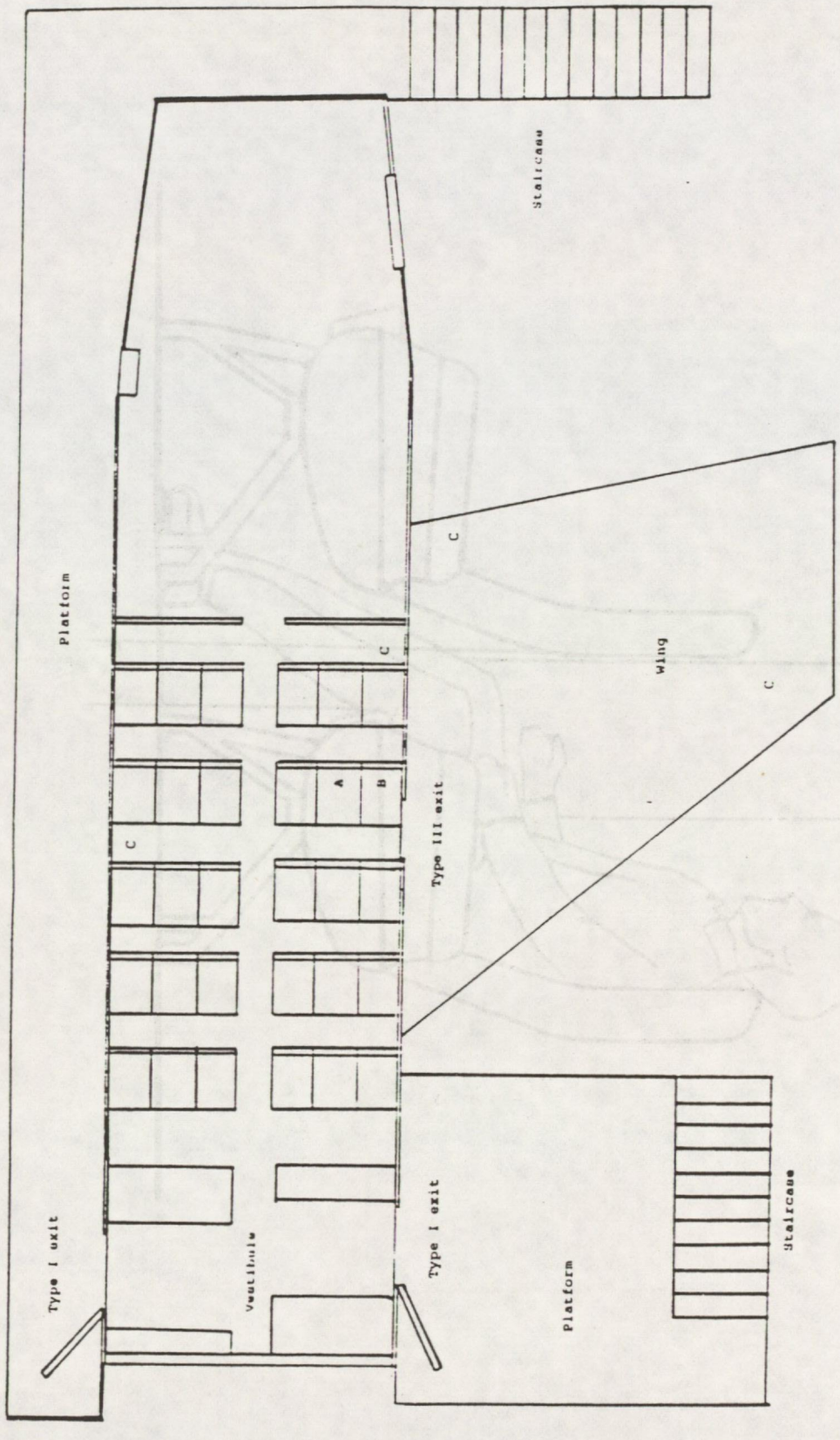

Figure 1 Plan view of cabin mock up

Appendix 2

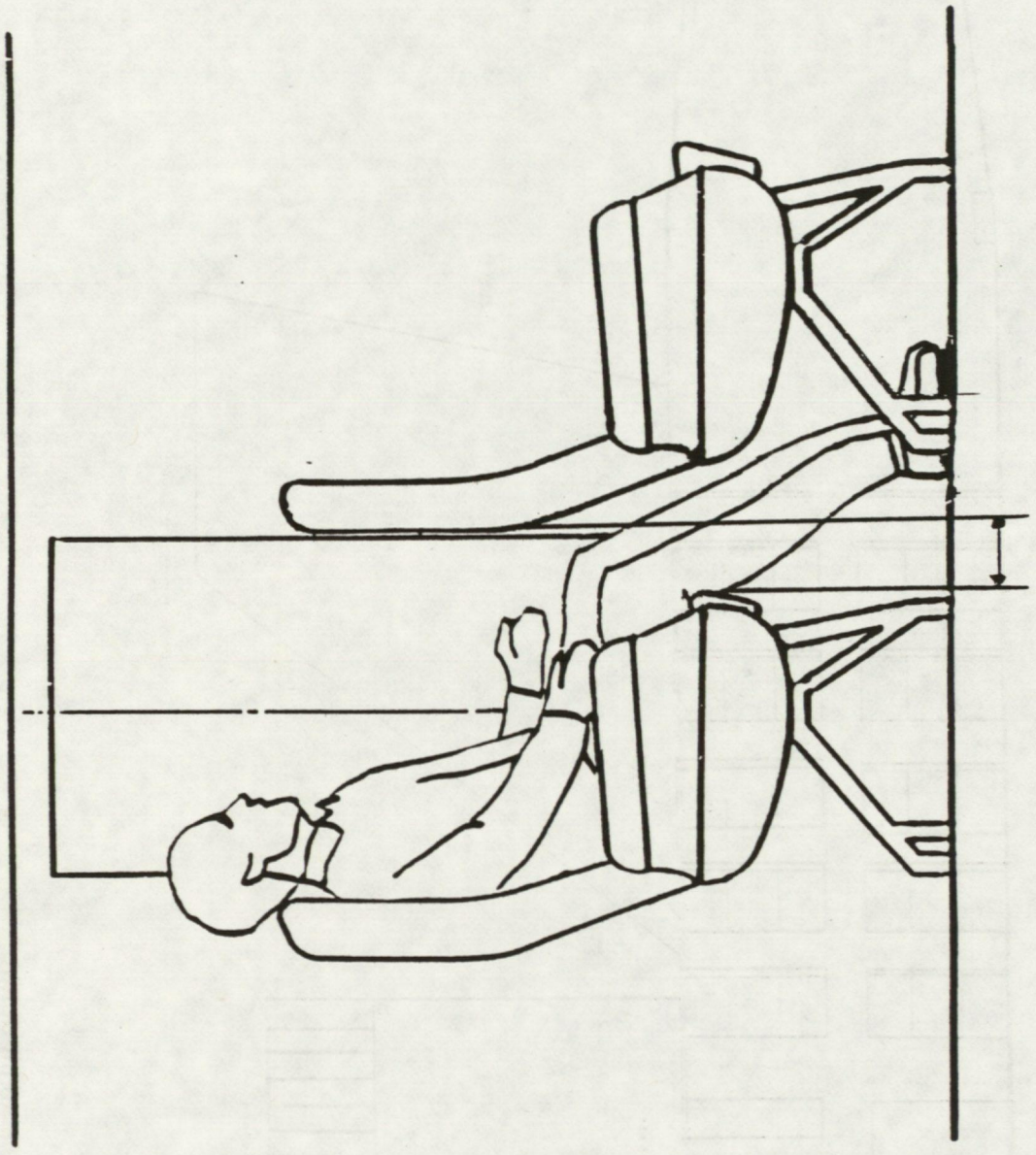

Figure 2 The pre-AN79 seating configuration

Appendix 3

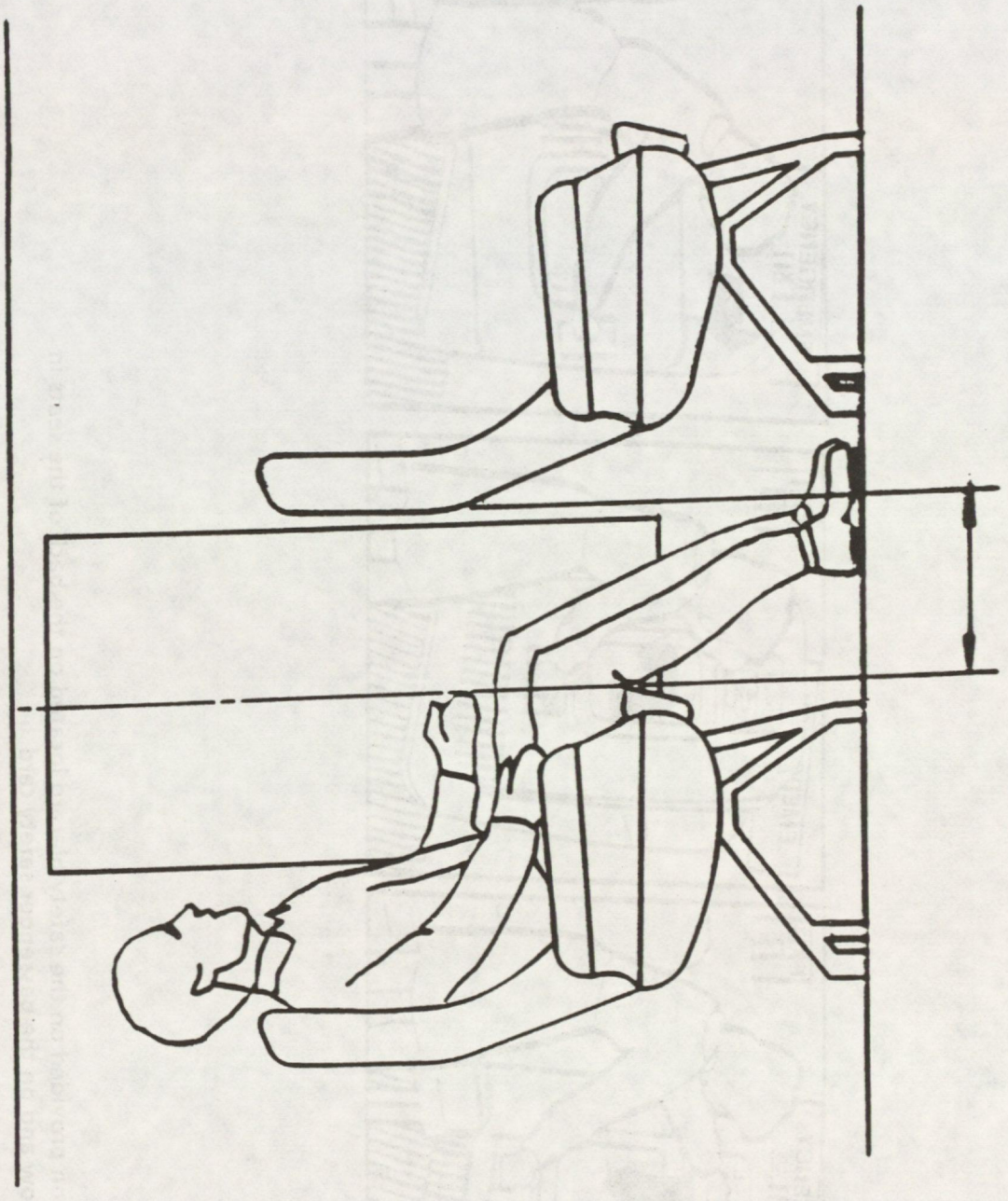

Figure 3 The AN79 seating configuration

Appendix 4

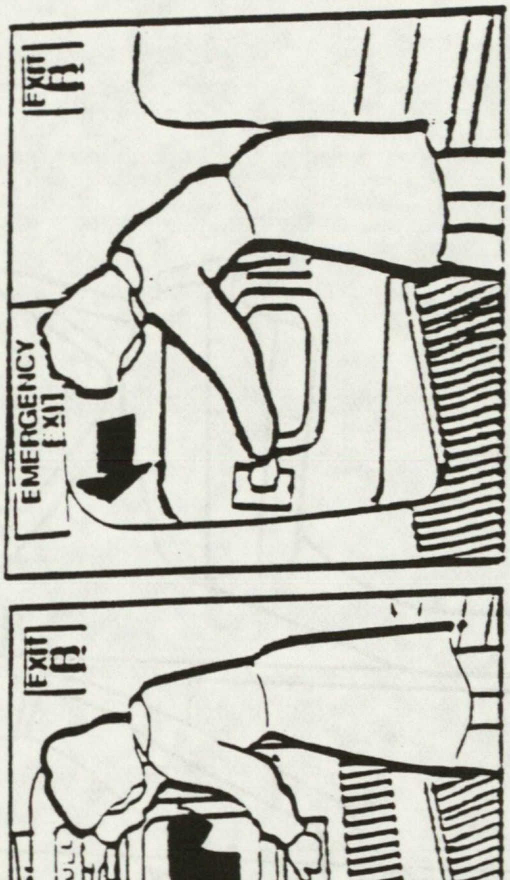

Figure 4 **Information provided on the safety placard located on the back of the seats in the exit row and on the passenger safety card**

Appendix 5

Questionnaire

Seat Number:..... Date:.....

1. Were you impeded in your access to the exit?

Yes ☐

No ☐

If no, go to question 2.
If yes, what were you impeded by?

.....

.....

2. In opening the exit and leaving the aircraft, please rate how easy or difficult you found the following by circling the appropriate number on the scale below:

	Very Easy						Very Difficult
the size of the exit	1	2	3	4	5	6	7
the weight of the exit	1	2	3	4	5	6	7
the position of the exit	1	2	3	4	5	6	7
clarity of the exit operating instructions	1	2	3	4	5	6	7
clarity of instructions for disposing of the door	1	2	3	4	5	6	7
exiting through overwing exit onto the wing	1	2	3	4	5	6	7

3. Did anything else impede you in operating the exit?

Yes	☐
No	☐

If no, go to question 4. If yes, what else impeded you?

.....

.....

4. Have you previously experienced any Cranfield aircraft trials?

Yes	☐
No	☐

5. How many times have you flown as an airline passenger before? (counting a return journey as one flight)

Never	☐
1-5	☐
6-10	☐
11-15	☐
15-20	☐
21-25	☐
26-30	☐
More than 30 times	☐

6. Have you ever experienced an aircraft emergency situation?

Yes ☐

No ☐

If yes, what kind of emergency situation was it?

.....

7. How often do you carry out strenuous physical exercise?

Once a day ☐

Less than once a day but more than twice a week ☐

1 or 2 times a week ☐

1 or 2 times a month ☐

Less than 1 or 2 times a month ☐

Thank you for taking part in these trials.

If you would be interested in taking part in any future trials carried out by the Applied Psychology Unit please complete the information on the attached sheet.

Appendix 6

Questionnaire 1

No:..... Seat Number:..... Date:.....

1. Did you have any difficulties in operating the exit?

Yes	☐
No	☐

If no, go to question 2.
If yes, what was it that caused the difficulty?

.....

.....

2. In opening the overwing exit and leaving the cabin, please rate how easy or difficult you found the following by circling the appropriate number on the scale below:

	Very Easy						Very Difficult
the weight of the overwing exit	1	2	3	4	5	6	7
the size of the overwing exit	1	2	3	4	5	6	7
location of exit in relation to your seat	1	2	3	4	5	6	7

3. Was the overwing exit lighter, the same weight, or heavier than you expected it to be?

Lighter	☐
Same	☐
Heavier	☐

4. From the end of the instruction to 'Open the exit and get out' how many seconds do you think that it took you to open the overwing exit?

Time in seconds:.....

5. Did you open and dispose of the exit in the manner indicated on the safety card?

Yes ☐

No ☐

6. Did you have any other problems in leaving the cabin?

.....

.....

7. Have you previously experienced any Cranfield aircraft trials?

Yes ☐

No ☐

8. Are you right or left handed?

Right ☐

Left ☐

9. How many times have you flown as an airline passenger before? (counting a return journey as one flight)

Never	☐
1-5	☐
6-10	☐
11-15	☐
16-20	☐
21-25	☐
26-30	☐
More than 30 times	☐

If never, go to question 11

10. What is the main purpose of your air travel?

Business	☐
Leisure	☐
Other (please specify)	☐

.....

11. How often do you carry out strenuous physical exercise?

Once a day	☐
Less than once a day but more than twice a week	☐
1 or 2 times a week	☐
1 or 2 times a month	☐
Less than 1 or 2 times a month	☐

Appendix 7

Questionnaire 2

No:..... Seat Number:..... Date:.....

1. Did you have any difficulties in operating the exit?

Yes ☐
No ☐

If no, go to question 2.
If yes, what was it that caused the difficulty?

.....

.....

2. Did examining the exit after the first trial affect the way in which you operated the exit the second time?

Yes ☐
No ☐

If no, go to question 3.
If yes, how did it affect you?

.....

.....

3. Did you open and dispose of the exit in the manner indicated on the safety card?

Yes ☐
No ☐

4. In opening the overwing exit and leaving the cabin, please rate how easy or difficult you found the following by circling the appropriate number on the scale below:

	Very Easy						Very Difficult
the weight of the overwing exit	1	2	3	4	5	6	7
the size of the overwing exit	1	2	3	4	5	6	7
location of exit in relation to your seat	1	2	3	4	5	6	7

5. From the end of the instruction to 'Open the exit and get out' how many seconds do you think that it took you to open the overwing exit?

Time in seconds;.....

Appendix 8

Questionnaire 3

No:..... Seat Number:..... Date:.....

1. Did you have any difficulties in operating the exit?

Yes ☐
No ☐

If no, go to question 2.
If yes, what was it that caused the difficulty?

.....

.....

2. Did examining the exit after the second trial affect the way in which you operated the exit the third time?

Yes ☐
No ☐

If no, go to question 3.
If yes, how did it affect you?

.....

.....

3. Did you open and dispose of the exit in the manner indicated on the safety card?

Yes ☐
No ☐

4. In opening the overwing exit and leaving the cabin, please rate how easy or difficult you found the following by circling the appropriate number on the scale below:

	Very Easy						Very Difficult
the weight of the overwing exit	1	2	3	4	5	6	7
the size of the overwing exit	1	2	3	4	5	6	7
location of exit in relation to your seat	1	2	3	4	5	6	7

5. From the end of the instructions to 'Open the exit and get out' how many seconds do you think that it took you to open the overwing exit?

Time in seconds:.....

Thank you for taking part in these trials. If you have any other comments that you would like to make please use the space below.

Appendix 9

Phase 1a and 1b - pre-AN79 and AN79 seating configuration

Volunteers' pre-test briefing

On arrival at Cranfield, a member of the research team, trained and dressed as a cabin attendant, briefed each volunteer as to the nature of the test.

Participants in Phase 1a were informed that they would be required to carry out a lifting task.

In Phase 1b, participants were informed that as part of the test they would be required to perform a lifting task on three occasions and that it would be the same lifting task each time.

Participants in both Phase 1a and 1b were males and females who were representative of the 0-50th percentile population range. All participants were warned that some people could find the task physically demanding. Each volunteer was therefore instructed that if they felt that they were experiencing difficulties in completing the task, that they should not feel obliged to continue.

During the briefing, each volunteer completed a consent form indicating that they understood the nature of the test and that they were not suffering from any medical ailments which might preclude them from taking part. In addition, each volunteer was weighed and measured by a member of the research team.

Each volunteer was briefed that, as a precaution, a fireman trained in First Aid would be present throughout the test. It was made clear to each volunteer that the presence of the fireman was simply to provide immediate attention should the volunteer injure themselves in any way whilst taking part in the test.

Finally, the member of the research team checked that each volunteer still felt that they were able to take part in the test.

Appendix 10

The safety briefing

Ladies and gentlemen. Welcome on board. For your personal safety and comfort any light articles which you have brought aboard the aircraft should be placed in the overhead lockers. Please ensure that hand luggage does not obstruct the aisles or any emergency exit. Passengers are asked to refrain from smoking until they are informed that they may do so by a member of cabin staff.

PAUSE

Ladies and gentlemen. May I ask you to pay special attention to this announcement which contains important information for your safety and comfort.

The emergency exit is clearly marked and is being pointed out to you. This is the emergency exit located in the centre of the main cabin. This can be observed on the safety leaflet in the seat pocket in front of you.

If the cabin staff should ask you to leave the aircraft urgently do not stop to collect your hand luggage. It must be left on the aircraft as it could seriously slow down your exit and that of other passengers. Please now ensure that your seat table is folded away, your seat back upright with the armrests down, and your seat belt tightly fastened.

We would also like to advise you of the emergency oxygen supply on board. Should additional oxygen be required throughout the cabin, the panel above your head will open automatically, and masks like these will drop down. There will be a certain amount of noise, so please do not be alarmed. Remain seated, pull the mask towards you, place over nose and mouth and breathe normally.

The cabin staff will now make their way through the cabin to check that all seat belts are fastened. The Captain would now like you to study the safety leaflets in the seat pocket in front of you. Thank you for your attention. We would like to wish you a pleasant flight.

PAUSE

'Open the exit and get out'

Appendix 11

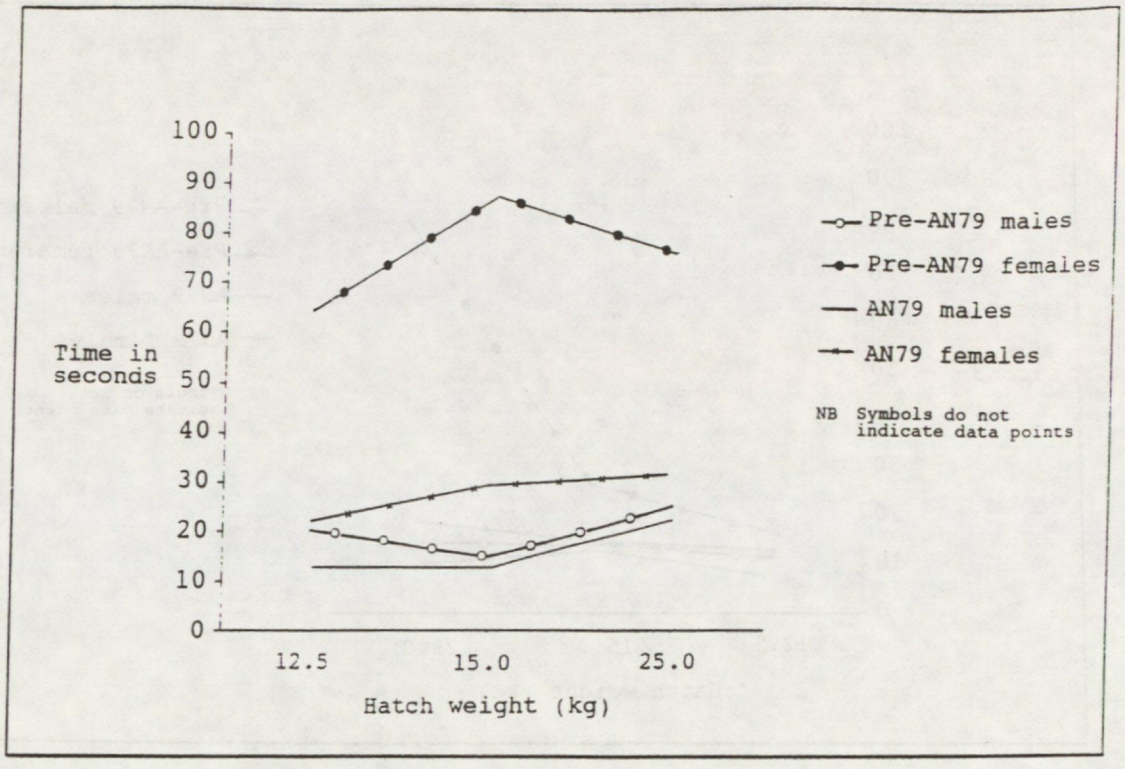

Figure 5 **Influence of hatch weight and seating configuration on the times taken by male and female volunteers to operate the hatch and evacuate onto the wing in the conditions with the dummy present – Phase 1a and 1b**

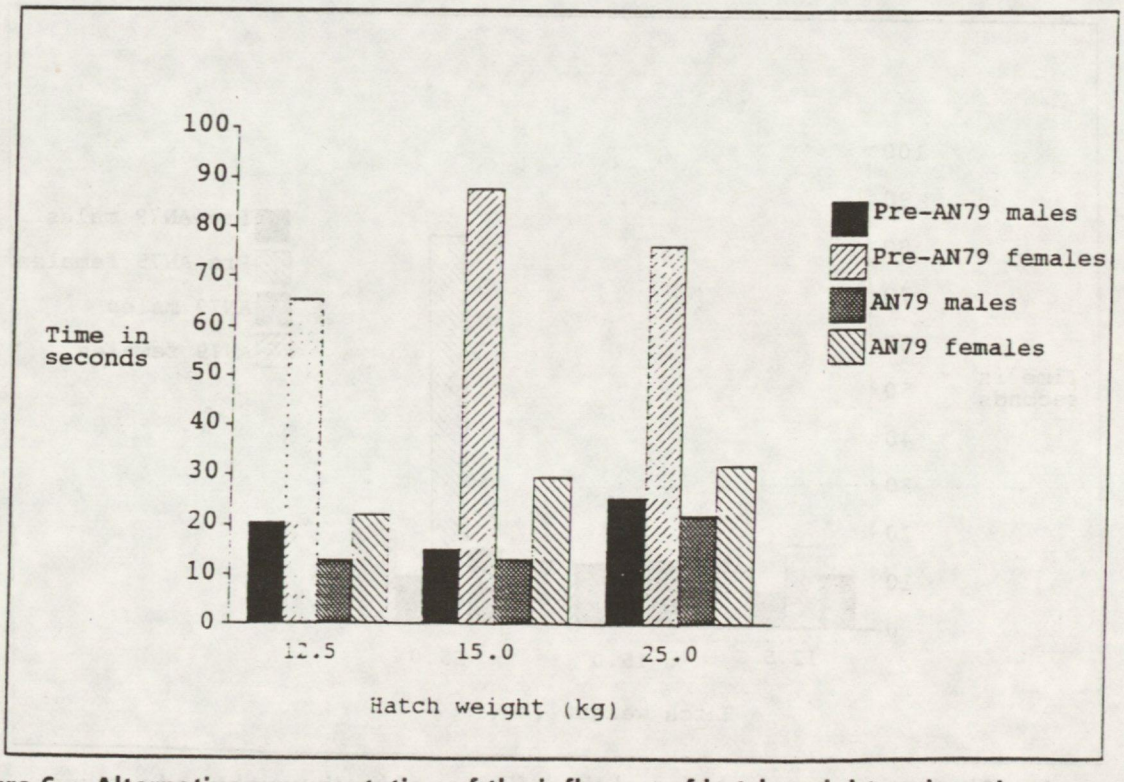

Figure 6 **Alternative representation of the influence of hatch weight and seating configuration on the times taken by male and female volunteers to operate the hatch and evacuate onto the wing in the conditions with the dummy present – Phase 1a and 1b**

Appendix 12

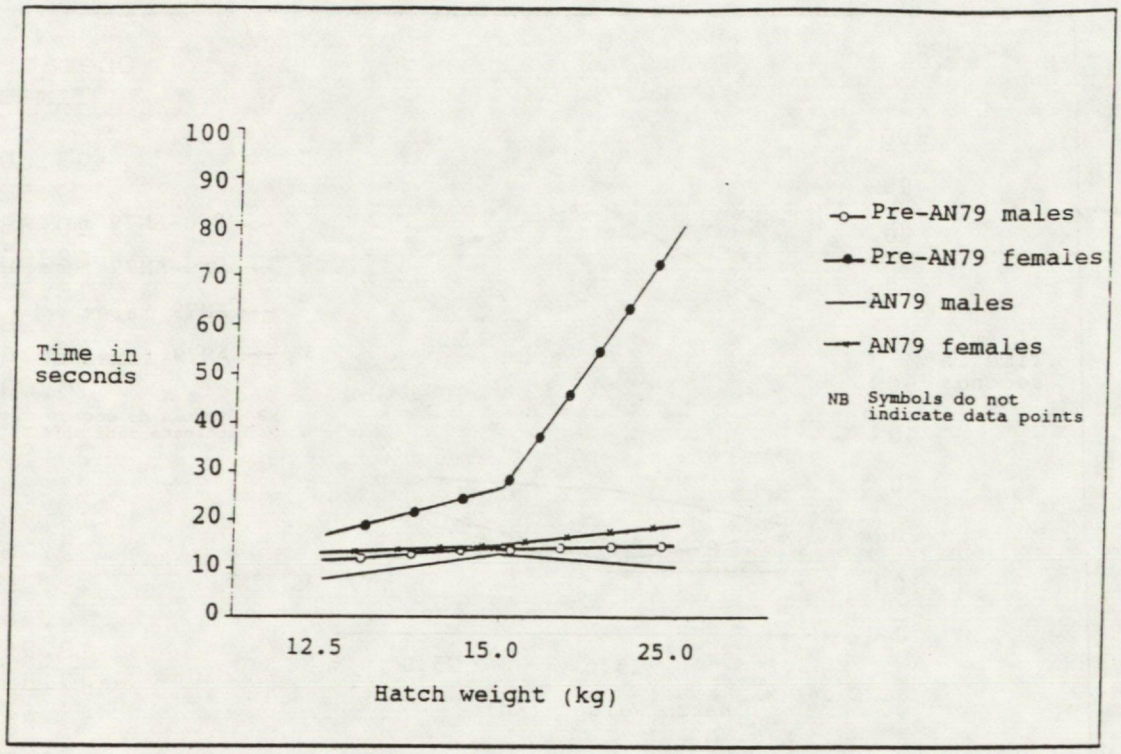

Figure 7 **Influence of hatch weight and seating configuration on the times taken by male and female volunteers to operate the hatch and evacuate onto the wing in the conditions without the dummy present – Phase 1a and 1b**

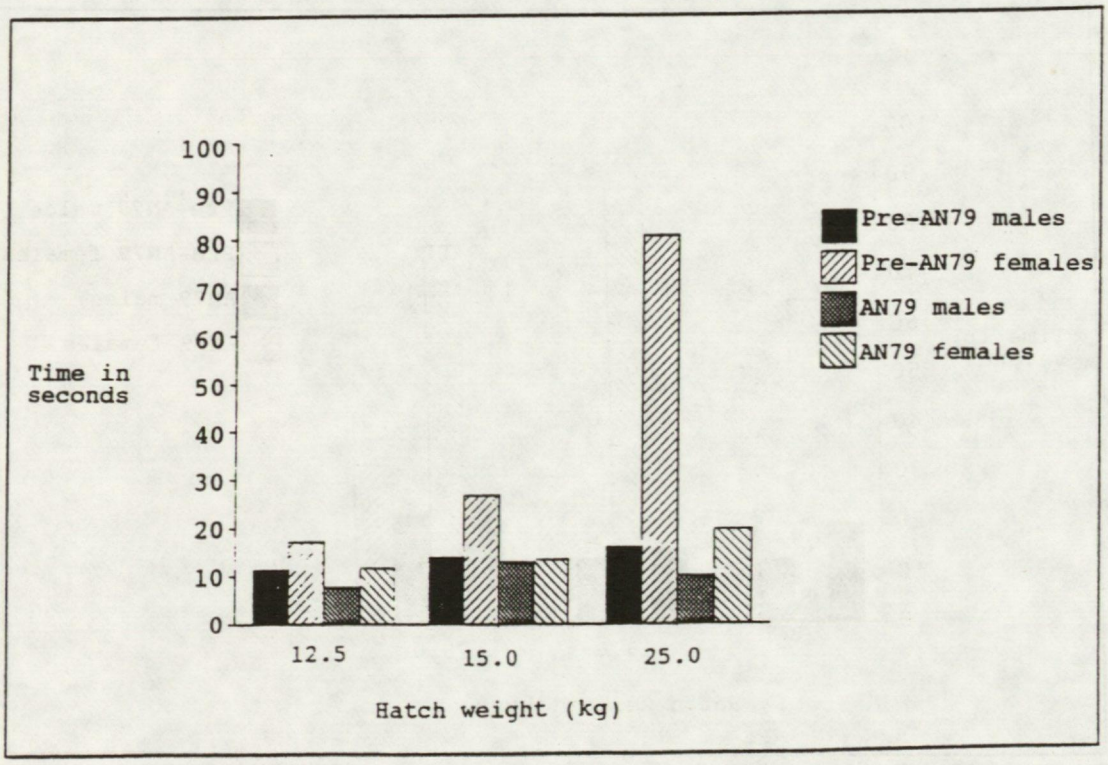

Figure 8 **Alternative representation of the influence of hatch weight and seating configuration on the times taken by male and female volunteers to operate the hatch and evacuate onto the wing in the conditions without the dummy present – Phase 1a and 1b**

Appendix 13

Phase 1a - Pre-AN79 tests - Type III hatch operation times

Volunteer Number	Age	Sex	Tall (cm)	Heavy (kg)	Hatch Weight	Dummy Y/N	Operation Times
1	22	M	171	73	15.0	Y	23.00
2	26	M	173	64	12.5	Y	9.52
3	28	M	171	68	25.0	Y	20.88
4	26	M	174	62	12.5	Y	18.00
5	35	F	155	50	12.5	Y	115.52
6	35	M	166	68	25.0	Y	14.28
7	47	F	162	55	12.5	N	16.76
8	35	M	167	64	12.5	N	10.00
9	23	F	156	58	15.0	N	22.04
10	28	M	169	64	25.0	N	20.96
11	21	F	159	51	25.0	N	21.64
12	24	M	167	61	15.0	N	19.96
13	29	M	162	65	15.0	N	32.76
14	25	M	166	61	25.0	N	11.28
15	49	M	169	70	15.0	Y	10.48
16	30	M	171	62	25.0	Y	18.96
17	23	M	169	71	12.5	Y	47.58
18	24	M	170	65	25.0	Y	42.64
19	21	M	168	65	15.0	Y	8.00
20	40	M	172	73	15.0	Y	28.15
21	27	F	151	49	25.0	Y	115.52
22	27	F	162	61	15.0	Y	115.52
23	22	M	171	67	12.5	Y	21.44
25	37	M	162	60	12.5	N	9.72
26	29	M	173	76	15.0	N	7.36
27	35	M	170	66	12.5	N	8.68
28	24	M	171	68	12.5	N	10.32
29	29	F	169	61	25.0	Y	36.90
30	24	M	176	66	12.5	Y	10.76
31	49	F	158	62	12.5	Y	9.96
32	31	F	157	45	15.0	Y	32.36
33	28	F	159	43	15.0	Y	115.52
34	36	F	164	52	12.5	Y	45.88
35	21	F	163	49	25.0	Y	115.52
36	45	M	172	65	25.0	N	13.76
37	22	F	159	54	25.0	N	115.52
38	39	M	167	69	15.0	N	8.60
39	21	F	169	63	12.5	N	11.00
40	28	M	166	68	25.0	N	16.76
41	23	M	166	58	25.0	N	6.64
42	43	M	174	66	25.0	N	9.84
44	40	F	158	57	12.5	Y	14.60
45	36	F	152	45	15.0	Y	115.52
46	25	M	172	59	15.0	Y	6.60
47	36	F	155	55	25.0	Y	115.52
48	49	M	166	62	25.0	Y	20.60
49	46	F	158	58	25.0	Y	60.30
50	28	F	156	57	12.5	Y	29.12

NB As volunteers 24 and 43 were oversized they were replaced by volunteers 97 and 98 and have not been included in the data

Phase 1a - Pre-AN79 tests - Type III hatch operation times

Volunteer Number	Age	Sex	Tall (cm)	Heavy (kg)	Hatch Weight	Dummy Y/N	Operation Times
51	38	F	159	48	15.0	Y	115.52
52	37	M	167	76	15.0	Y	8.96
53	30	F	155	59	25.0	N	115.52
54	26	M	174	50	12.5	N	9.12
55	38	F	159	61	15.0	N	14.88
56	41	M	170	62	12.5	N	10.88
57	21	F	157	51	12.5	N	22.28
58	42	F	156	56	25.0	N	18.80
59	31	F	163	64	15.0	N	38.04
60	36	F	157	63	12.5	N	11.20
61	49	F	161	54	15.0	N	60.48
62	22	M	172	75	15.0	N	11.24
63	27	F	164	54	12.5	Y	115.52
64	25	M	169	72	12.5	Y	26.36
65	54	F	156	49	25.0	Y	32.64
66	51	F	150	50	15.0	Y	115.52
67	42	F	159	47	12.5	Y	115.52
68	44	M	170	67	25.0	Y	19.56
69	44	M	163	63	25.0	Y	51.48
70	41	F	159	54	25.0	Y	115.52
71	26	M	170	70	15.0	Y	19.76
72	34	F	154	55	25.0	N	115.52
73	36	F	158	48	12.5	N	18.04
74	48	M	168	67	15.0	N	12.44
75	44	F	160	62	15.0	N	24.44
76	35	F	162	56	25.0	N	27.12
77	32	M	172	62	25.0	N	29.00
78	19	F	160	51	12.5	N	22.28
79	24	M	171	77	15.0	N	7.96
80	44	M	173	68	12.5	N	11.00
81	42	F	164	62	25.0	Y	18.08
82	22	F	163	48	15.0	Y	78.20
83	40	F	150	60	12.5	Y	76.20
84	35	F	158	56	15.0	Y	12.36
85	39	F	163	56	12.5	N	21.36
86	48	F	163	60	15.0	N	26.04
87	26	M	165	63	25.0	N	19.08
88	42	M	174	72	12.5	Y	17.16
89	29	M	160	56	15.0	Y	15.48
90	44	M	173	70	12.5	Y	13.12
91	23	M	177	62	25.0	Y	16.36
92	24	F	165	50	15.0	N	9.12
93	32	M	168	65	12.5	N	21.12
94	23	F	155	47	25.0	N	115.52
95	41	M	167	54	15.0	N	10.60
96	31	F	152	68	12.5	N	13.68
97	34	F	158	54	25.0	N	115.52
98	40	F	159	48	15.0	N	17.40

Although the dummy was present in half of the test conditions only 18 of the 48 volunteers in the pre-AN79 tests attempted to lift or move the dummy in order to operate the Type III hatch. Three of these volunteers were subsequently unable to complete the task so their times have not been included in the Table.

Phase 1a - Pre-AN79 tests - Time in seconds taken by each volunteer to lift/move dummy prior to operation of Type III hatch

Volunteer Number	Time in seconds
15	2.28
17	32.12
18	15.64
19	21.36
20	21.25
29	30.94
32	53.04
48	9.00
64	15.88
68	44.04
71	18.28
81	18.52
82	14.80
83	71.28
88	14.40

Phase 1b - AN79 Tests 1, 2 and 3 - Type III hatch operation times

Volunteer Number	Age	Sex	Tall (cm)	Heavy (kg)	Hatch Weight	Dummy Y/N	Operation Times Test 1	Test 2	Test 3
101	32	F	164	64	15.0	N	8.32	4.52	4.08
102	25	F	158	53	12.5	N	17.24	6.84	6.32
103	39	F	161	58	12.5	N	13.60	6.28	7.84
104	43	M	168	61	12.5	N	10.52	5.08	5.28
105	36	M	176	61	12.5	N	9.96	13.00	9.68
106	20	M	171	67	15.0	N	8.44	11.32	7.24
107	30	M	172	65	15.0	N	27.68	10.24	10.32
108	40	M	168	66	15.0	N	18.04	5.20	3.92
109	39	F	163	53	12.5	N	8.84	21.12	11.36
110	30	F	154	51	15.0	N	10.00	19.12	9.20
111	25	F	156	49	12.5	N	9.12	6.96	62.36
112	23	M	170	62	15.0	N	7.36	5.56	5.36
113	23	M	173	61	15.0	N	4.72	5.28	3.80
114	26	F	159	51	15.0	N	19.72	45.36	32.56
115	26	F	150	50	12.5	N	10.48	9.16	9.96
116	41	M	174	74	12.5	N	5.48	4.64	3.84
117	29	F	152	58	15.0	N	10.48	6.00	5.36
118	29	M	170	63	15.0	N	16.68	6.80	6.80
119	22	M	172	66	15.0	N	6.56	11.72	6.08
120	36	F	155	41	25.0	N	18.04	17.24	19.84
121	21	M	168	68	25.0	N	12.72	17.68	10.20
122	22	F	153	49	25.0	N	30.36	39.36	62.36
123	35	M	169	73	25.0	N	9.36	5.48	6.24
124	37	M	169	70	25.0	N	8.60	5.68	7.12
125	30	F	160	53	25.0	N	18.04	10.52	9.12
126	49	F	156	63	15.0	N	12.20	12.52	14.48
127	37	F	160	49	15.0	N	8.84	8.48	8.60
128	33	M	173	76	25.0	N	12.60	6.04	5.12
129	42	M	173	73	12.5	N	5.96	4.96	6.04
130	32	F	158	52	12.5	N	7.28	4.80	5.32
131	42	M	167	64	15.0	N	13.60	4.04	4.20
132	35	M	159	55	25.0	N	21.24	14.92	14.08
133	40	F	157	62	15.0	N	11.04	9.16	12.20
134	23	M	171	63	25.0	N	10.20	5.52	6.88
135	49	F	161	58	12.5	N	12.44	7.60	8.12
136	39	M	170	70	12.5	N	10.80	8.68	7.32
137	46	M	169	72	12.5	N	4.84	4.08	3.92
138	25	M	166	62	25.0	N	10.16	6.56	8.28
139	23	M	168	62	25.0	N	6.24	5.88	7.40
140	25	M	172	69	12.5	N	6.16	3.92	6.28
141	28	F	155	51	15.0	N	26.08	7.72	8.00
142	25	F	156	55	25.0	N	17.60	9.32	11.56
143	20	F	153	57	12.5	N	13.20	8.28	7.52
144	39	F	156	52	25.0	N	13.68	11.04	7.80
145	35	F	155	55	12.5	Y	41.32	25.40	11.00
146	25	M	174	63	12.5	Y	14.04	4.56	3.80
147	44	F	164	57	25.0	Y	10.92	8.36	8.76
148	25	F	158	57	15.0	Y	13.48	18.56	11.40
149	41	F	160	58	15.0	Y	51.12	23.80	19.52
150	25	F	157	54	15.0	Y	19.04	36.88	25.72
151	26	M	170	66	12.5	Y	22.52	9.08	5.96
152	34	F	160	56	12.5	Y	26.44	21.84	6.36
153	49	M	170	61	15.0	Y	22.28	7.48	6.48
154	33	F	162	59	15.0	Y	42.76	16.32	10.16
155	44	F	158	66	25.0	Y	20.12	51.68	24.88
156	33	M	169	59	15.0	Y	9.84	51.68	48.12
157	26	F	160	57	25.0	Y	51.12	51.68	62.36
158	34	M	169	75	25.0	Y	22.72	51.32	20.20
160	26	M	175	64	25.0	Y	19.68	14.60	14.16
161	30	F	155	65	12.5	Y	9.92	10.76	10.80
162	46	F	162	57	12.5	Y	9.36	51.68	8.08
163	31	M	167	57	12.5	Y	10.04	5.80	5.52
164	24	M	169	77	12.5	Y	11.24	7.12	7.96
165	23	M	168	60	25.0	Y	20.92	40.56	29.84
166	22	M	172	59	25.0	Y	48.56	13.48	13.40
167	36	F	164	57	25.0	Y	39.10	14.00	16.80
168	33	F	160	55	15.0	Y	8.80	45.58	9.60
169	31	F	156	51	15.0	Y	51.12	20.92	45.88
170	43	F	160	52	12.5	Y	42.24	18.00	42.44
172	26	M	171	62	15.0	Y	12.68	10.84	14.80
173	26	F	161	63	12.5	Y	13.68	10.92	10.88
174	24	M	174	67	25.0	Y	18.72	8.56	7.44
175	37	M	172	62	15.0	Y	10.96	8.64	7.28
176	23	M	164	58	12.5	Y	7.92	6.56	5.32
177	37	M	169	67	15.0	Y	13.24	8.32	7.12
178	32	F	154	54	25.0	Y	32.48	21.08	12.36
179	35	F	162	59	12.5	Y	15.16	13.12	13.44
180	37	F	156	58	15.0	Y	20.32	13.96	9.04

NB As volunteers 159 and 171 were oversized they were replaced by volunteers 197 and 198 and have not been included in the data

Appendix 13 (continued)

Phase 1b – AN79 Tests 1, 2 and 3 – Type III hatch operation times

Volunteer Number	Age	Sex	Tall (cm)	Heavy (kg)	Hatch Weight	Dummy Y/N	Operation Times Test 1	Test 2	Test 3
181	31	M	171	73	25.0	Y	20.88	7.76	6.60
182	36	M	170	72	12.5	Y	9.60	8.00	6.36
183	41	F	160	60	25.0	Y	35.88	22.50	12.88
184	27	F	159	56	12.5	Y	17.64	13.12	11.80
185	43	M	174	62	15.0	Y	12.08	10.72	9.36
186	20	M	176	65	12.5	Y	14.44	21.88	19.76
187	47	F	153	52	25.0	Y	46.36	26.36	26.40
188	33	M	172	66	25.0	Y	11.72	8.08	9.76
189	20	F	161	47	15.0	Y	30.16	14.80	15.48
190	20	M	168	68	12.5	Y	13.04	9.88	9.12
191	49	M	169	65	25.0	Y	12.40	13.84	10.28
192	35	M	172	61	15.0	Y	8.24	11.92	5.36
193	24	F	165	64	25.0	Y	18.97	9.88	11.48
194	43	M	166	62	15.0	Y	15.64	6.28	6.28
195	30	F	163	51	25.0	N	28.84	23.44	13.60
196	38	M	166	54	25.0	N	9.80	6.00	7.16
197	23	F	158	62	25.0	N	9.24	20.72	13.80
198	28	M	170	55	12.5	N	7.52	4.96	7.44

The dummy was present in half of the test conditions. Only 12 of the 48 volunteers in Test 1 of the AN79 tests attempted to lift or move the dummy in order to operate the Type III hatch. Seven volunteers attempted to move the dummy in Test 2 and 5 in Test 3. Volunteer 157 moved the dummy in Test 1 but was unable to complete the task so her time has not been included in the Table.

Phase 1b – AN79 tests – Time in seconds taken by each volunteer to lift/move dummy prior to operation of Type III hatch

Volunteer Number	Time in seconds Test 1	Test 2	Test 3
48	13.36	–	–
49	32.00	–	–
53	28.92	5.96	11.72
55	23.12	1.44	5.60
56	17.44	–	–
58	–	3.68	6.88
59	5.08	–	–
60	15.80	–	–
62	–	2.20	–
66	–	16.40	–
67	24.20	2.48	2.36
68	16.92	–	–
72	6.84	–	–
77	26.90	16.14	20.06

Appendix 14

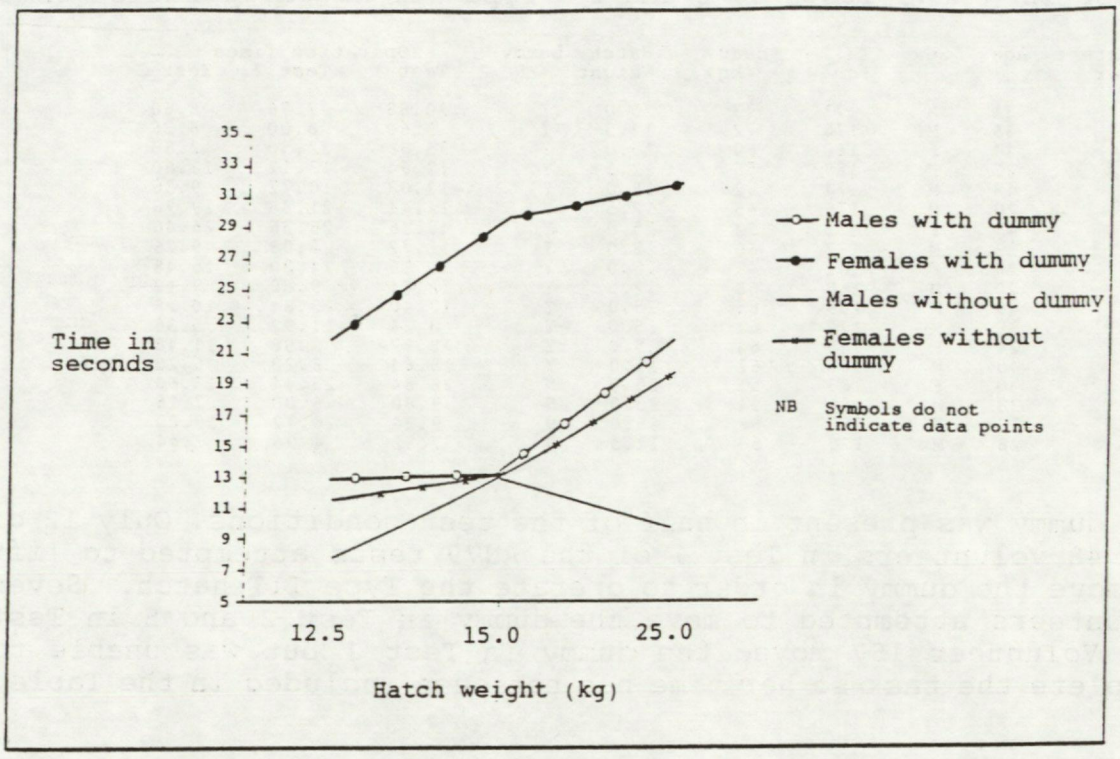

Figure 9 Mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 1

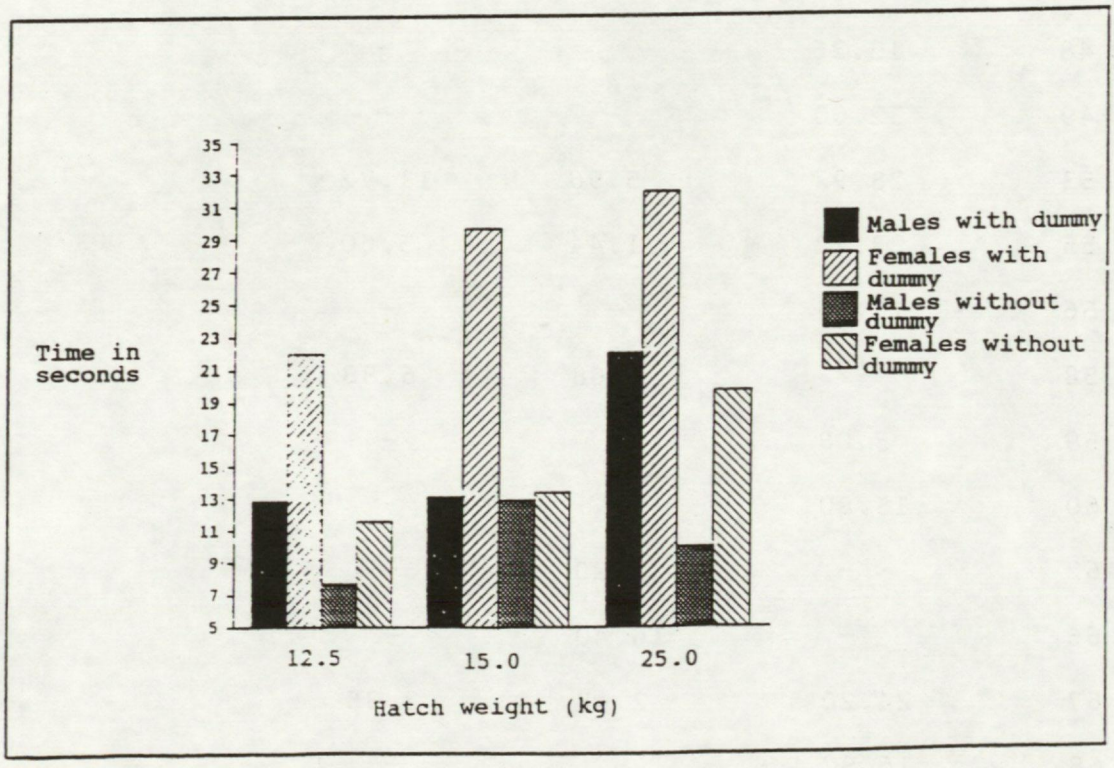

Figure 10 Alternative representation of the mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 1

Appendix 15

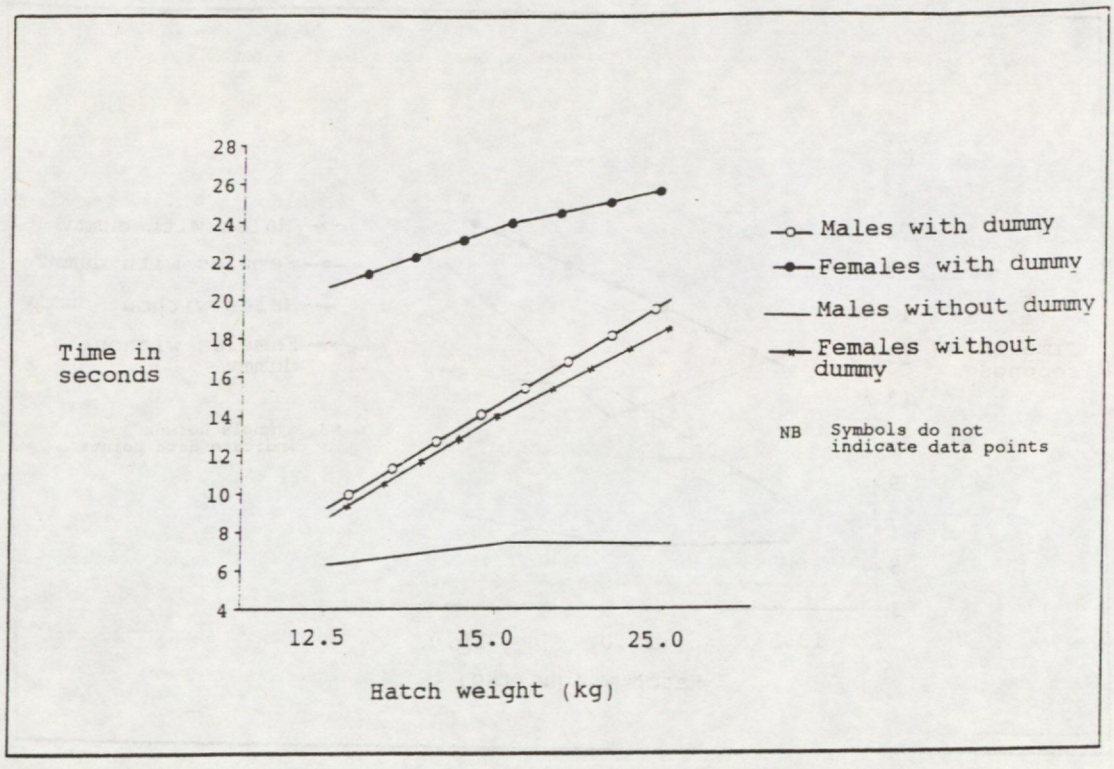

Figure 11 Mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 2

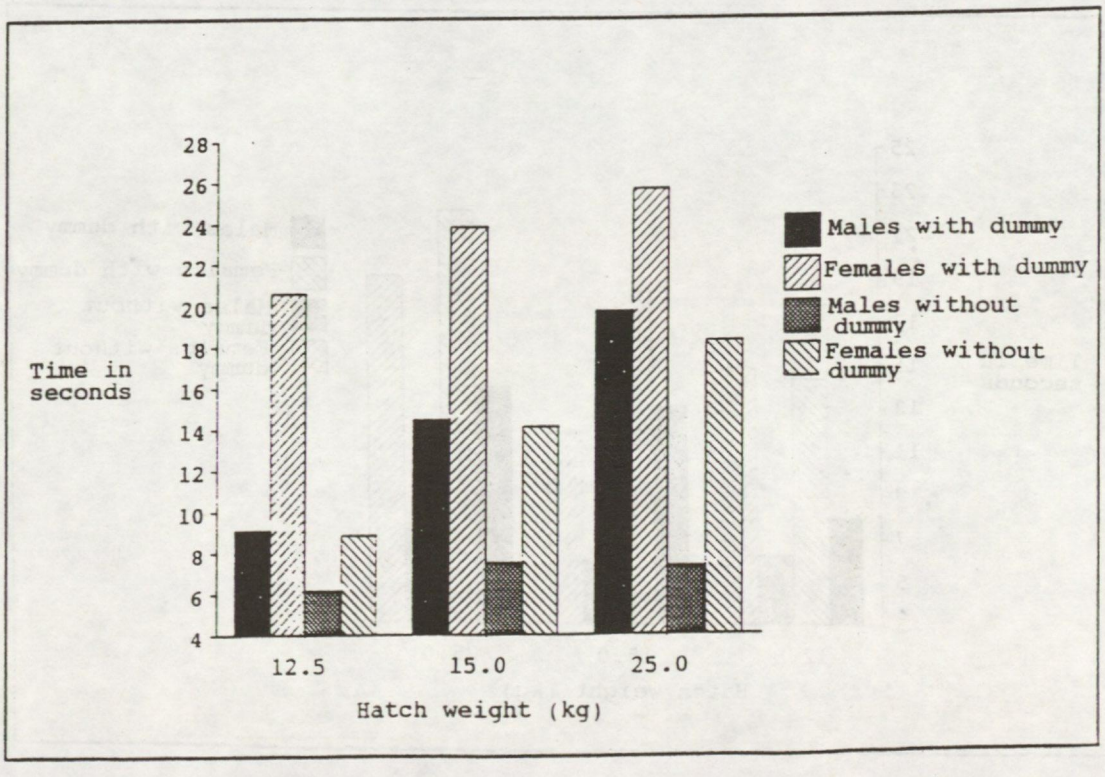

Figure 12 Alternative representation of the mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 2

Appendix 16

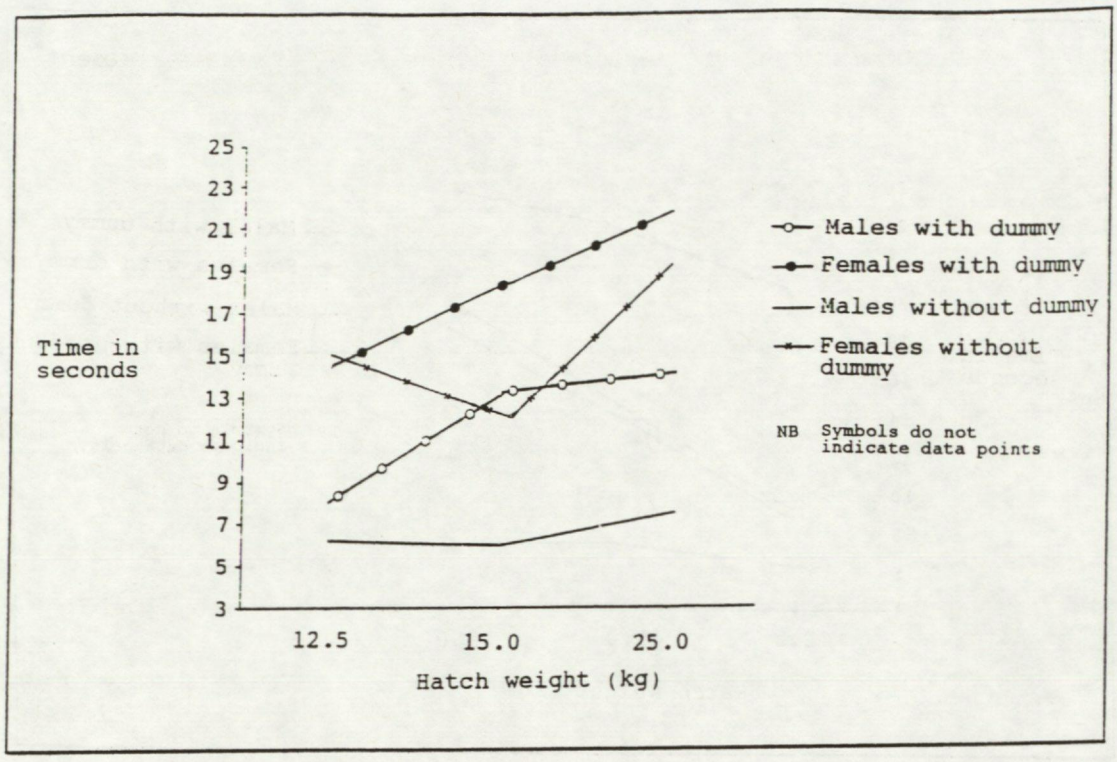

Figure 13 Mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 3

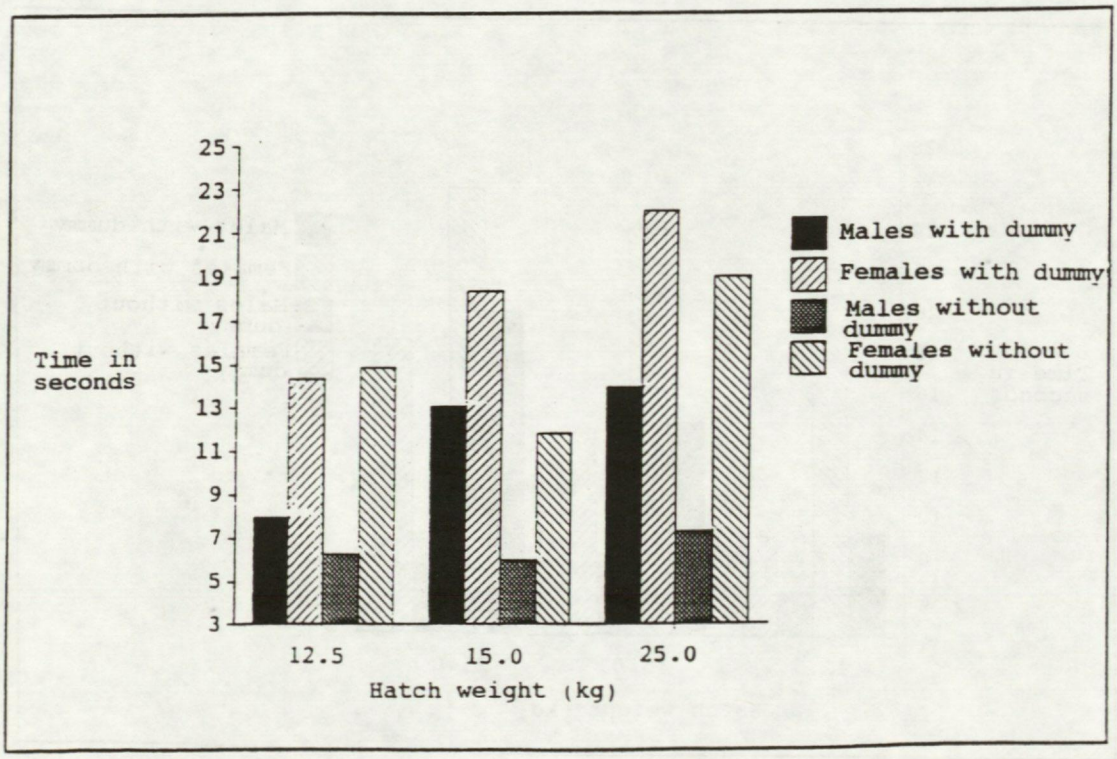

Figure 14 Alternative representation of the mean times taken to operate the hatch and evacuate onto the wing in Phase 1b – AN79 seating configuration, Test 3

Appendix 17

Table 17.1 Influence of practice in experimental conditions with the dummy present

Hatch Weight (kg)	*Test 1*		*Test 2*		*Test 3*	
	M	*F*	*M*	*F*	*M*	*F*
12.5	12.86	21.97	9.11	20.61	7.98	14.35
15.0	13.12	29.61	14.49	23.85	13.10	18.35
25.0	21.95	31.87	19.76	25.69	13.96	21.99

Table 17.2 Mean times and significance levels for all volunteers in Tests 1, 2 and 3

	Mean	*Number of cases*	*t value*	*Degrees of freedom*	*2-tail probability*
Test 1	21.90	48	1.18	47	NS
Test 2	18.92	48			
Test 1	21.90	48	3.78	47	.001
Test 3	14.95	48			
Test 2	18.92	48	2.32	47	.025
Test 3	14.95	48			

Appendix 18

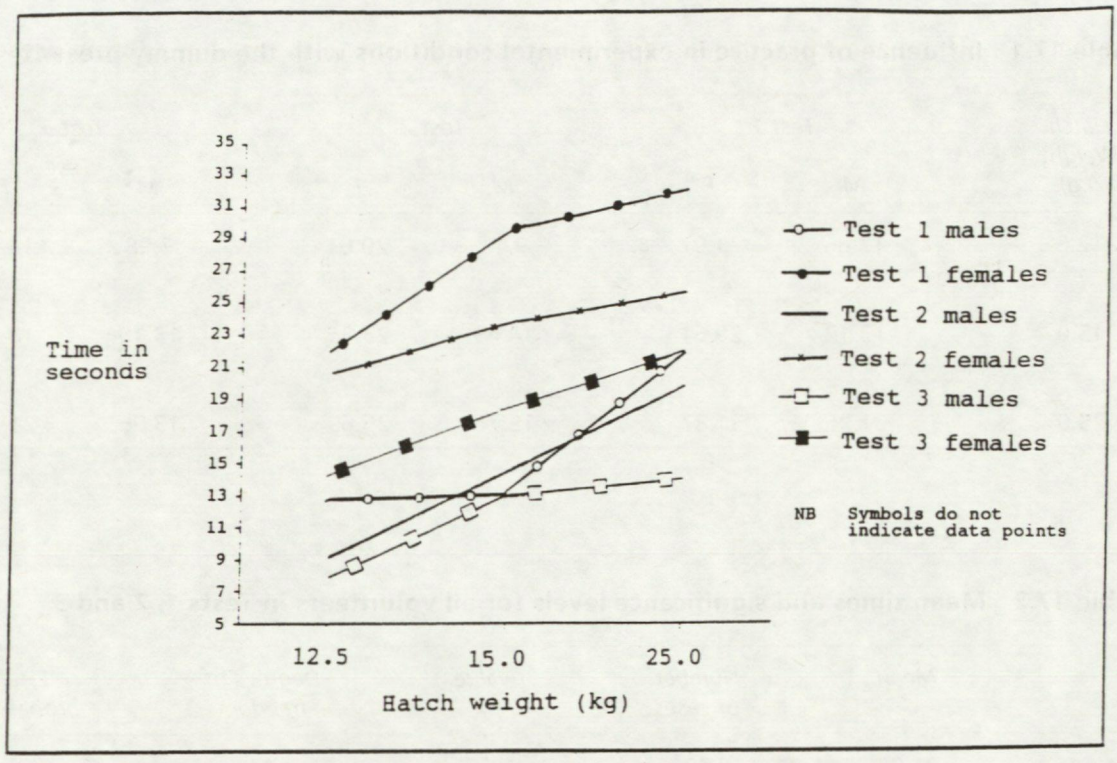

Figure 15 Influence of practice on times taken to operate the hatch and evacuate onto the wing in the conditions with the dummy present – Phase 1b (AN79)

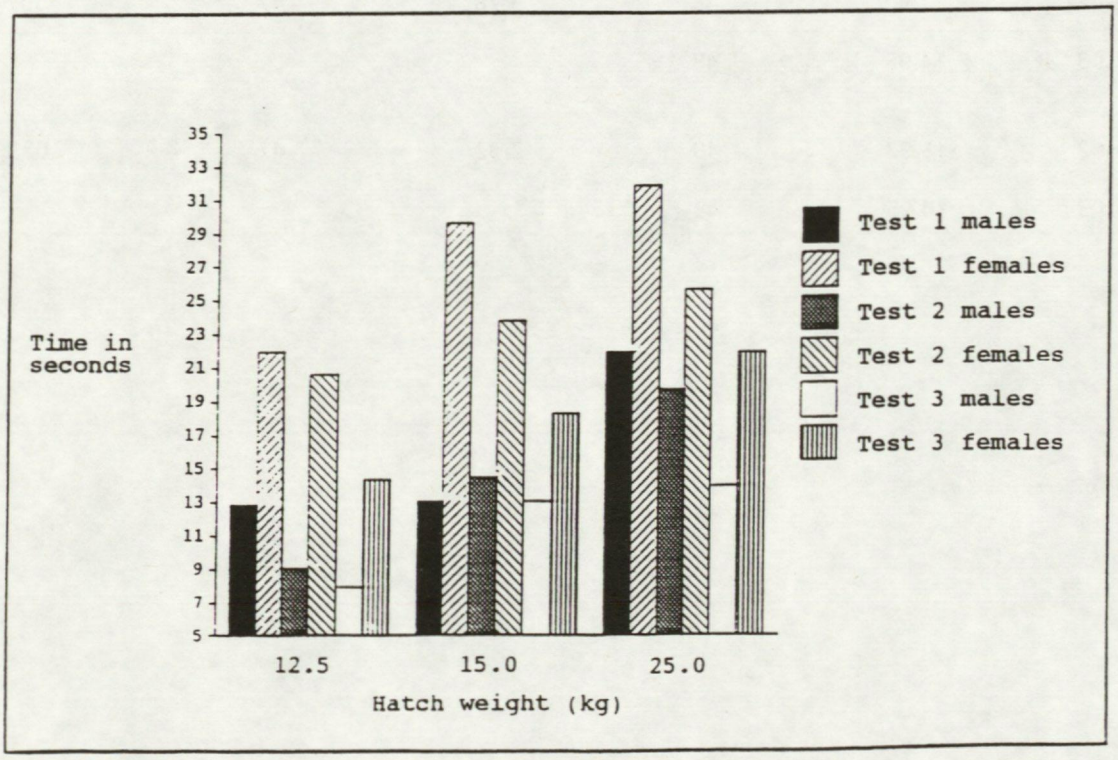

Figure 16 Alternative representation of the influence of practice on times taken to operate the Type III hatch and evacuate onto the wing in the conditions with the dummy present – Phase 1b (AN79)

Appendix 19

Table 19.1 Influence of practice in experimental conditions without the dummy present

Hatch Weight (kg)	*Test 1*		*Test 2*		*Test 3*	
	M	*F*	*M*	*F*	*M*	*F*
12.5	7.66	11.53	6.17	8.88	6.23	14.85
15.0	12.88	13.33	7.52	14.11	5.96	11.81
25.0	9.96	19.63	7.36	18.32	7.30	19.02

Appendix 20

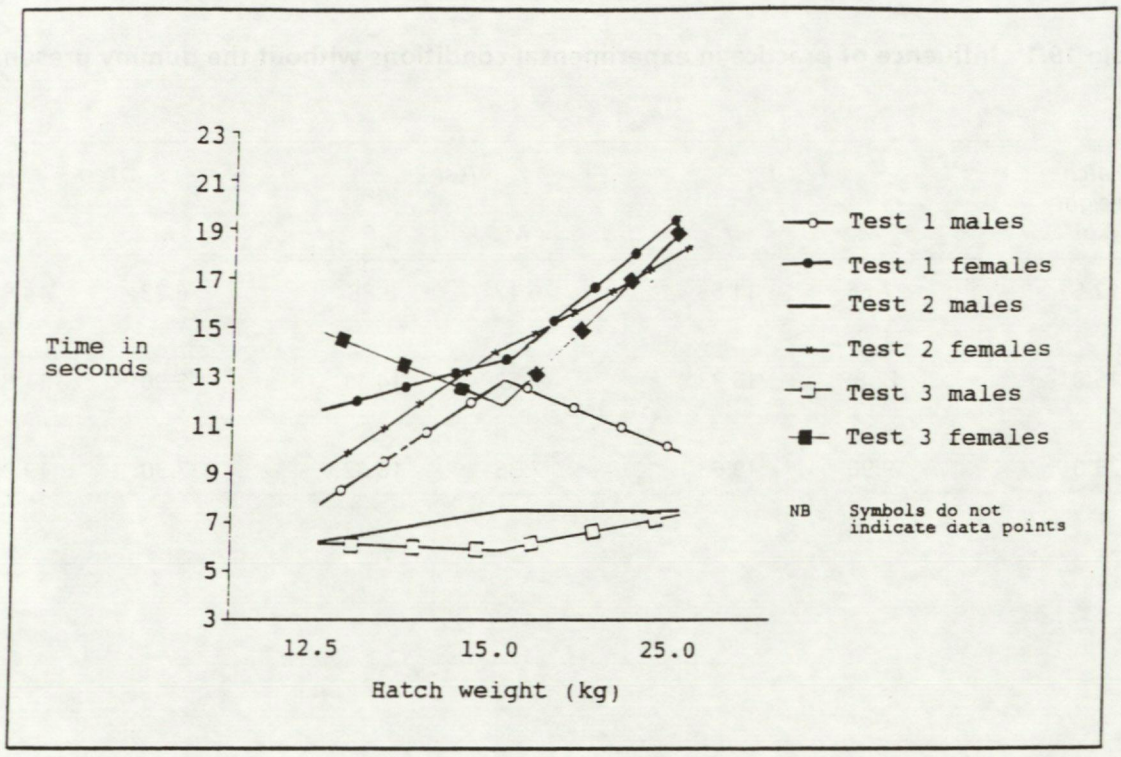

Figure 17 Influence of practice on times taken to operate the hatch and evacuate onto the wing in the conditions without the dummy present – Phase 1b (AN79)

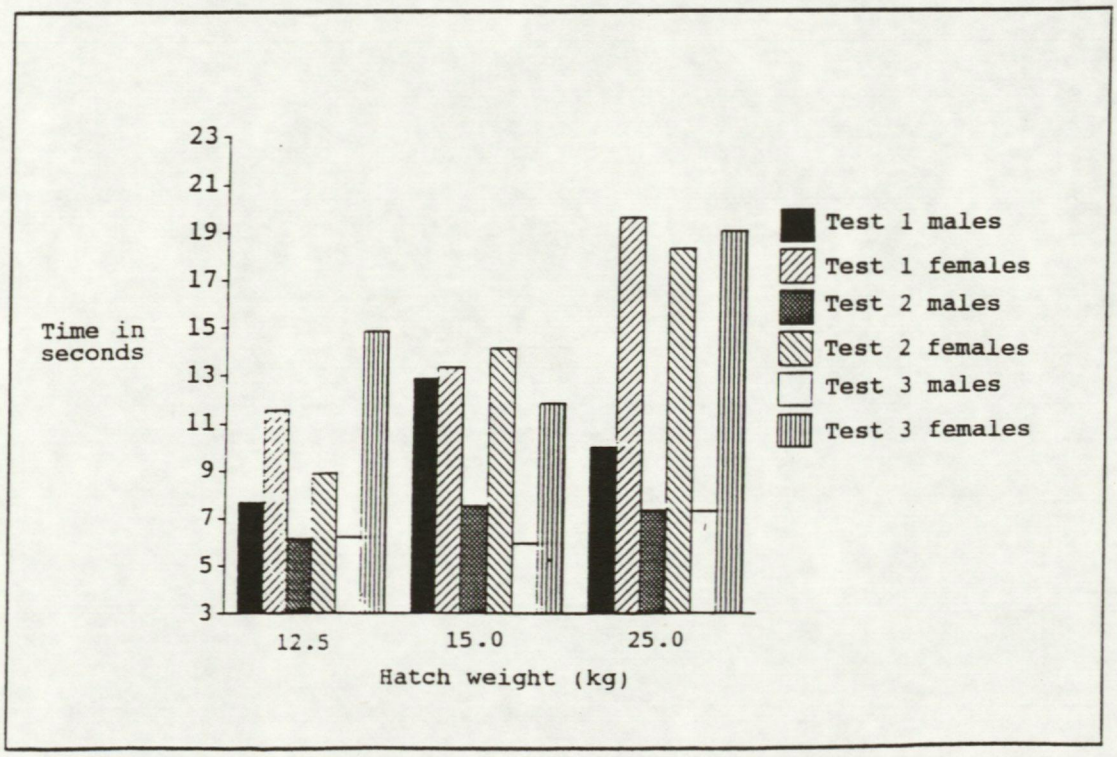

Figure 18 Alternative representation of the influence of practice on times taken to operate the Type III hatch and evacuate onto the wing in the conditions without the dummy present – Phase 1b (AN79)