Recent Transport Canada cabin safety research at Cranfield University

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Transport Canada has funded cabin safety research programmes within the Human Factors Group at Cranfield University for a number of years. Recent programmes have addressed issues such as potential improvements to the conventional operating mechanism of the Type III exit and evacuations from regional jet configurations.

Firstly, the Type III exit was used in experiments to establish whether there was any significant difference between 2x2 and 3x3 seating configurations, due to the additional confinements in regional jet configurations. Then, two potential improvements to the conventional Type III exit operating mechanism were investigated in separate experiments. In one, a modification to the operating handle was made, such that it did not retract back once it had been operated. This meant, in effect, that it became fixed, and could be used as a second hand-hold. The third experiment investigated passenger evacuations through the Type III exit when an "up-and-over" automatically disposed hatch was installed.

1. Introduction

Snow, Carroll and Allgood (1970) suggested that a number of factors influence passenger survival in the event of an emergency evacuation. They placed these factors into four categories – procedural, environmental, biobehavioural and configurational. Procedural factors relate to the regulatory and training practices governing the evacuation situation. This may include the level of experience and training of the crew, and the standard operating procedures of the airline. The environmental factors include elements inside and outside the aircraft that may influence the evacuation. Examples include the presence of smoke or fire, and the weather conditions outside the aircraft. Biobehavioural factors are the factors relating to the passengers themselves, and include sex, age, physical state and level of motivation. Configurational variables relate to the physical features and layout of the cabin, and include aisle width, seating density, the number and location of exits, and the type of exit.

One major focus of research into factors influencing survival has been the Type III exit. These exits are self-help exits, and they are intended to be operated by passengers in the event of an emergency. However, it is known that passengers may have great difficulty making these exits available in emergency situations. At Manchester in 1985, the passenger seated adjacent to the Type III exit only began to open it at the instigation of other passengers. She tried to open the hatch by pulling the armrest mounted on the seat, in the mistaken belief that this was the operating handle. The passenger seated next to her reached over and released the hatch, whereupon it fell inwards, trapping them both in their seats. A passenger in the row behind lifted the hatch onto a vacant seat, making the exit available. A total of 27 people then evacuated through the Type III exit, including one child and an infant-in-arms (King, 1988).

Since the Manchester accident, research into operation of the Type III exit has included work to investigate access to the exit (e.g. McLean, 2001), experiments to investigate improvements to the exit operating mechanism (e.g. Cobbett, Jones & Muir, 1997), and trials to examine the effect of briefing passengers in the Type III exit row (e.g. Cobbett, Liston & Muir, 2001). However, much of this work has related to aircraft with seats in a 3x3 configuration, that is, with three seats either side of the main aisle. Relatively little is known about whether research findings from trials conducted in a 3x3 configuration will generalise to aircraft with a 2x2 configuration, that is, an aircraft configuration with two seats each side of the main aisle. This issue is of relevance because regional jets have a narrower fuselage, and therefore less cabin width and lower headroom.

Transport Canada commissioned and funded three preliminary studies into the operation of the Type III exit in 2x2 configurations. The first was an initial study to investigate whether there were any significant differences in Type III exit availability times and evacuation times under 2x2 and 3x3 cabin configurations. The second study was conducted to investigate whether a more minor modification to the operating handle of a conventional Type III exit hatch afforded significant time savings to the exit operator. The third study compared the operation of an automatically disposed hatch to the operation of a conventional Type III hatch in a 2x2 configuration. All studies were conducted using the Boeing 737 cabin simulator at Cranfield University in the United Kingdom.

2. Type III exit availability and evacuation times under 2x2 and 3x3 cabin configurations

2.1. Test facility

For tests in the 3x3 condition, seating triples were set at 29″ pitch, equivalent to a vertical projection of between 3 and 4 inches. The lower line of overhead lockers was 164 cm above the cabin floor. The only modifications required were changes to the width of the passageway at the Type III exit, which was tested at 10 inch and 13 inch vertical projection. For the 2x2 configuration tests, the Boeing 737 cabin simulator was modified to a 2x2 configuration. Seating doubles from an Embraer 120 regional jet were placed at a vertical projection of 3.5 inches, to be equivalent to tests conducted in the 3x3 configuration. The fuselage was narrowed by installation of a false wall down the port side. The overhead lockers were fitted with false bases to lower the ceiling, and reduce the headroom available. The bases of the overhead lockers were 139 cm above the cabin floor.

2.2. Participants

Twenty four independent groups of up to twenty members of the public were recruited as participants via local and regional advertising. To minimise the risk of injury, participants were required to be aged between 20 and 50, and relatively fit. For safety reasons, participants with any of the following medical conditions were restricted from taking part: heart disease, high blood pressure, fainting or blackouts, diabetes, epilepsy or fits, deafness, chronic back pain, ankle swelling, depression, anxiety, other nervous/psychiatric illnesses, fear of enclosed spaces, fear of heights, fear of flying, brittle bones, asthma, bronchitis, breathlessness, chest trouble, allergy, lumbago sciatica, or any other serious illness. Volunteers who were pregnant, or who thought they may be pregnant, were also excluded from participating, as were volunteers who had recently undergone surgery or who were receiving medical treatment.

All participants were required to weigh no more than 15 stones/95.25 kg. Participants who had previous experience of operating a Type III exit were excluded from taking part. Each group was required to take part in a single evacuation to eliminate any learning and practise effects from the results.

2.3. Experimental design

There were two independent variables in the study. The first was the seating configuration, which was either a 2x2 configuration or a 3x3 configuration. The second independent variable was the passageway width at the Type III exit, which was either 10 or 13 inches vertically projected. Twenty four experimental trials were conducted with up to twenty participants in each group. The experimental schedule is shown in Table 1.

Table 1: Experimental schedule

	Seating configuration	
Passageway width	**3x3**	**2x2**
10 inch vertical projection	6 groups	6 groups
13 inch vertical projection	6 groups	6 groups

The dependent variable was elapsed time from the call to evacuate, which was "Undo your seatbelts and get out!". The dependent variable measure was extracted from time coded video footage of the trials. The time taken for the participant to operate the Type III exit and make it available for egress was extracted from the video footage, as was the evacuation time (which was the time from the call to evacuate to the point where the participant had both feet on the wing).

2.4. Procedure

On arrival at the test session, participants were issued with a bib detailing their seat number, and were also provided with a clipboard containing the paperwork for the trials. The height and weight of all participants was measured and documented by the research team. Each participant completed a medical questionnaire, which was checked and signed by the evacuation nurse. Participants were then briefed with regards to the nature of the trials, health and safety considerations including the emergency stop procedure, and payment details. On completion of the briefing, participants boarded the cabin simulator. Seats for each group were pre-allocated according to a random seating plan, with the exception that the participant in the seat adjacent to the Type III exit was always male.

Once participants were seated, the member of cabin crew provided a safety briefing which included the location of the exits, and demonstrations of the use of seatbelts and oxygen masks. In addition, the participant seated next to the Type III exit received an individual briefing on their emergency duties, which included the instruction that they were not to open the exit unless a member of cabin crew instructed them to do so. When the safety briefings were complete, a pre-recorded evacuation scenario was then played. This included a period of engine noise, followed by an announcement from the Captain to "Undo your seat belts and get out!".

At this point, the cabin crew member, who was located at the front of the cabin, commanded passengers to open the Type III exit. Passengers were urged to move quickly throughout the evacuation. The cabin crew member used assertive, concise, positive commands, in accordance with the findings of Muir & Cobbett (1996). A number of stewards were located outside the exit, in order that evacuating passengers could be moved swiftly away. The evacuation was deemed complete when all passengers had evacuated the cabin. Participants were then asked to complete a post-evacuation questionnaire. On completion of the questionnaires, participants were thanked, debriefed and paid.

2.5. Results

A total of 439 participants took part in the testing programme. 274 were male (62.4%), 162 were female (36.9%), with 3 participants not answering the question. 435 participants (99.1% of the sample) provided their age at the time of the testing session. Participants' ages ranged from 20 to 54 years, with a mean age of 28.9 years, and a standard deviation of 7.8 years. 42 participants were left handed (9.6%), 381 were right handed (86.8%), 13 were ambidextrous (3%), with 3 participants (0.7%) of the sample not answering the question. Most participants had flown previously on a commercial flight (425 participants, or 96.8%), and one participant reported having to make an emergency evacuation.

In total, all twenty four planned evacuations were conducted, with no reported injuries. Twelve trials were conducted in each cabin configuration (2x2 and 3 x 3). Within each configuration, six trials were conducted with a 10" vertical projection at the Type III exit and six were conducted with a 13" vertical projection at the Type III exit. Twenty participants and a number of reserves were recruited for each test session, although on several occasions participants failed to attend. This led to the number of participants within each trial varying across the testing sessions, from a minimum of fifteen to a maximum of twenty.

The video footage was edited and time coded. All timings were taken from the Captain's command to "Undo your seatbelts and get out!". The time taken for the Type III exit operator to make the exit available for egress was extracted from the video footage. Egress times for each participant were also extracted from the video footage, the timings were taken from the call to evacuate until the point where each participant had both feet upon the wing.

2.5.1. Evacuation times

Since the group size varied due to non-attendance, all evacuation time analyses used only the times for the first 15 people to evacuate through the Type III exit. Mean evacuation times for the first fifteen people to evacuate in each condition are given in Table 2. These times include Type III exit operation times.

Table 2: Mean evacuation times (in seconds) for the first fifteen participants to egress through the Type III exit in each condition.

	Seating configuration		Total
Passageway width	**3x3**	**2x2**	
10 inch vertical projection	19.0 (sd 5.8)	18.1 (sd 5.3)	**18.6 (sd 5.6)**
13 inch vertical projection	18.8 (sd 5.7)	17.3 (sd 4.9)	**18.1 (sd 5.3)**
Total	**18.9 (sd 5.7)**	**17.7 (sd 5.1)**	

As can be seen in Table 2, the evacuation times for the first fifteen participants vary by test condition. In order to assess the statistical significance of these differences, a factorial analysis of variance (ANOVA) was conducted on the data. The results are shown in Table 3. Again, it should be noted that this analysis includes the time taken to make the Type III exit available for evacuation.

Table 3: ANOVA results for the time taken for the first fifteen participants to evacuate through the Type III exit, by seating configuration and passageway width.

Source	Sum of squares	df	Mean square	F	p
Main effects					
Configuration	133.22	1	133.22	4.52	0.03
Vertical projection	20.83	1	20.83	0.70	0.40
Interaction					
Configuration by vertical projection	6.18	1	6.18	0.21	0.64
Error	10493.97	356	29.47		
Total	131566.24	360			

The results in Table 3 indicate that there were statistically significant differences in the times taken for the first 15 people to evacuate due to the seating configuration. The mean times demonstrate that participants evacuated quicker in the 2x2 configuration than the 3x3 configuration. The probability of this result having occurred by chance alone is less than five in one hundred.

2.5.2. Exit availability times

In order to examine the effects of seating configuration and vertical projection on the time taken to make the Type III exit available, these data were analysed separately. The time taken to make the exit available was defined as the time taken from the call to evacuate, until the exit was available for evacuation. Mean exit availability times for each condition are shown in Table 4.

Table 4: Mean time (in seconds) to make the Type III exit available in each condition.

	Seating configuration		Total
Passageway width	**3x3**	**2x2**	
10 inch vertical projection	10.2 (sd 3.0)	8.1 (sd 1.6)	**9.1 (sd 2.5)**
13 inch vertical projection	9.4 (sd 2.1)	8.6 (sd 0.8)	**9.0 (sd 1.6)**
Total	**9.8 (sd 2.5)**	**8.4 (sd 1.2)**	

As can be seen in Table 4, there are some differences in the time taken to make the exit available between conditions. To assess the statistical significance of these differences, a factorial analysis of variance (ANOVA) was conducted on the data. The results are shown in Table 5.

Table 5: ANOVA results for the time taken to make the Type III exit available, by seating configuration and passageway width.

Source	Sum of squares	df	Mean square	F	p
Main effects					
Configuration	12.18	1	12.18	2.91	0.10
Vertical projection	0.12	1	0.12	0.02	0.86
Interaction					
Configuration by vertical projection	2.22	1	2.22	0.53	0.47
Error	83.71	20	4.18		
Total	2069.33	24			

The results in Table 5 indicate that there were no statistically significant differences in the time taken for participants to make the exit available for evacuation due to the seating configuration or vertical projection.

3. The effect of a modification to the Type III exit operating handle in 2x2 and 3x3 configurations

3.1. Test facility

The test facility was the Boeing 737 cabin simulator located at Cranfield University. The facility is fitted with a fully functional Type III exit in the starboard side of the fuselage. During this testing programme, the conventional Type III exit hatch was operated under two conditions. In one series of trials, the release lever on the hatch was not fixed, and therefore the release lever retracted into its aperture after exit operation. In a second series of tests, the release lever was modified, so that it became fixed after exit operation. In effect, this modification made it possible for the operating lever to function as a fixed and rigid handle.

For tests in the 3x3 condition, seating triples were set at 29″ pitch, equivalent to a vertical projection of between 3 and 4 inches. The bases of the overhead lockers were 164 cm above the cabin floor. For the 2x2 configuration tests, the facility was modified. The fuselage was narrowed by installation of a false wall down the port side. The overhead lockers were fitted with false bases to lower the ceiling, and reduce the headroom available. The bases of the overhead lockers were 139 cm above the cabin floor.

3.2. Participants

Forty individuals were recruited as participants, with each participant being tested individually. All participants were recruited via local and regional advertising, and, as with the first study described, there were certain restrictions on participation for medical and insurance reasons.

3.3. Experimental design

There were two independent variables in the research study. The first was the seating configuration, which was either a 2x2 configuration or a 3x3 configuration. The second independent variable was the handle operating mechanism of the Type III exit. In one condition, the release lever on the hatch was not fixed, and therefore the release lever retracted into its aperture after exit operation. In the second condition, the release lever was modified, so that it became fixed after exit operation. In effect, this modification made it possible for the operating lever to function as a fixed and rigid handle. The experimental schedule, showing how the forty evacuation trials were run in the four test conditions, is given in Table 6. In fact, each participant took part in two trials, one with the conventional handle, and one with the handle modified. The order in which participants completed the trials was counterbalanced to avoid practise and learning effects. However, only the results from the first trial - with naïve participants - are reported here.

Table 6: Experimental schedule (first trial only)

	Handle modification	
Configuration	**Retracted (conventional)**	**Fixed (modified)**
3x3	10 trials	10 trials
2x2	10 trials	10 trials

The dependent variable was extracted from time coded video footage of the trials. The dependent variable for evacuation time was elapsed time from the call to evacuate, which was "Undo your seatbelts and get out!" to when the participant had both feet upon the aircraft wing. The dependent variable for exit availability was the time taken for the participant to operate the Type III exit and make it available for egress.

3.4. Procedure

On arrival at the test session, participants were issued with a bib detailing their volunteer number, and were also provided with a clipboard containing the paperwork for the trials. The height and weight of all participants was measured and documented by the research team. Each participant completed a medical questionnaire, which was checked and signed by the evacuation nurse. Participants were then briefed with regards to the nature of the trials, health and safety considerations including the emergency stop procedure, and payment details. On completion of the briefing, the participant boarded the cabin simulator, each participant sat in the seat adjacent to the Type III exit.

Once participants were seated, the member of cabin crew provided a safety briefing which included the location of the exits, and demonstrations of the use of seatbelts and oxygen masks. In addition, the participant received an in-depth individual briefing on their emergency duties. This briefing included specific instructions on the physical actions required to open the exit, and the briefing also included the instruction that they were not to open the exit unless a member of cabin crew instructed them to do so. When the safety briefings were complete, a pre-recorded evacuation scenario was then played. This included a period of engine noise, followed by an announcement from the Captain to "Undo your seat belts and get out!".

At this point, the cabin crew member, who was located at the front of the cabin, commanded passengers to open the Type III exit. Passengers were urged to move quickly throughout the evacuation. The cabin crew member used assertive, concise, positive commands, in accordance with the findings of Muir & Cobbett (1996). A number of stewards were located outside the exit, in order that evacuating passengers could be moved swiftly away. Participants were then asked to complete a post-evacuation questionnaire. On completion of the questionnaire, participants were thanked, debriefed and paid.

3.5. Results

A total of 40 participants took part in the testing programme. 26 were male (65%) and 14 were female (35%). Participants' ages ranged from 22 to 49 years, with a mean age of 28.3 years, and a standard deviation of 7.5 years. 4 participants were left handed (10%), 34 were right handed (85%) and 2 participants were ambidextrous (5%). Most participants had flown previously on a commercial flight (39 participants, or 97.5%), and one participant reported having to make an emergency evacuation. In total, all forty planned evacuations were conducted, with no reported injuries.

The video footage was edited and time coded. All timings were taken from the Captain's command to "Undo your seatbelts and get out!". Evacuation times were extracted from the time coded footage, from the call to evacuate until the point where each participant had both feet upon the wing. The time taken for the participant to operate the Type III exit and make it available for egress was also extracted from the footage.

3.5.1. Evacuation times

Mean evacuation times for each condition are given in Table 7. These times include the time taken to operate the Type III exit.

Table 7: Mean evacuation times (in seconds) to egress through the Type III exit in each condition.

	Handle modification		Total
Configuration	**Retracted (conventional)**	**Fixed (modified)**	
3x3	12.8 (sd 3.8)	12.3 (sd 3.1)	**12.5 (sd 3.4)**
2x2	15.4 (sd 4.2)	17.9 (sd 6.1)	**16.7 (sd 5.2)**
Total	**14.1 (sd 4.1)**	**15.1 (sd 5.5)**	

As can be seen in Table 7, the evacuation times vary by test condition. In order to assess the statistical significance of these differences, a factorial analysis of variance (ANOVA) was conducted on the data. The results are shown in Table 8. Again, it should be noted that this analysis includes the time taken to make the Type III exit available for evacuation.

Table 8: ANOVA results for participants to evacuate through the Type III exit, by handle modification and seating configuration.

Source	Sum of squares	df	Mean square	F	p
Main effects					
Configuration	170.56	1	170.56	8.71	0.00
Handle modification	9.60	1	9.60	0.49	0.48
Interaction					
Configuration by handle	21.31	1	21.31	1.09	0.30
Error	704.29	36	19.56		
Total	9426.34	40			

The results in Table 8 indicate that there were statistically significant differences at the 0.05 level in the times taken to evacuate, due to the seating configuration. The mean times demonstrate that participants evacuated quicker in the 3x3 configuration than the 2x2 configuration.

3.5.2. Exit availability times

In order to examine the effects of seating configuration and handle modification on the time taken to make the Type III exit available, these data were analysed separately. The mean exit availability times for each condition are shown in Table 9.

Table 9: Mean time (in seconds) to make the Type III exit available in each condition.

	Handle modification		Total
Configuration	**Retracted (conventional)**	**Fixed (modified)**	
3x3	11.0 (sd 3.6)	10.3 (sd 2.9)	**10.6 (sd 3.2)**
2x2	13.3 (sd 2.8)	15.7 (sd 5.8)	**14.5 (sd 4.6)**
Total	**12.1 (sd 3.4)**	**13.0 (sd 5.2)**	

As can be seen in Table 9, there are some differences in times taken to make the exit available for evacuation. In order to assess the statistical significance of these differences, a factorial analysis of variance (ANOVA) was conducted on the data. The results are shown in Table 10.

Table 10: ANOVA results for the time taken to make the Type III exit available by seating configuration and handle modification.

Source	**Sum of squares**	**df**	**Mean square**	**F**	**p**
Main effects					
Configuration	150.54	1	150.54	9.66	0.00
Handle	7.92	1	7.92	0.50	0.48
Interaction					
Configuration by Handle	25.28	1	25.28	1.62	0.21
Error	561.05	36	15.58		
Total	7054.94	40			

The results in Table 10 indicate that there were statistically significant differences in the times taken to make the exit available, due to the seating configuration. The mean times demonstrate that participants made the Type III exit available more quickly in the 3x3 configuration than the 2x2 configuration.

4. A comparison between the conventional Type III exit and an automatically disposed hatch in a 2x2 cabin configuration

4.1. Test facility

The Type III exit in the Boeing 737 cabin simulator at Cranfield University was modified for the experiment. The conventional Type III hatch was fitted with a mechanism to convert the conventional operation to an "up-and-over" style automatically disposed hatch, as used in previous research (e.g. Cobbett, Muir & Jones, 1997). The "up-and-over" hatch slid into the overhead lockers, rather than flipping outside against the fuselage. The Type III exit hatch in either in the conventional or modified configuration was used for all evacuations in this programme.

For all tests, the facility was modified into a 2x2 configuration. The fuselage was narrowed by installation of a false wall down the port side. The overhead lockers were fitted with false bases to lower the ceiling, and reduce the headroom available. The bases of the overhead lockers were 139 cm above the cabin floor. Seating doubles from an Embraer 120 regional jet were used.

4.2. Participants

Eighty individuals were recruited as participants, with each participant completing the evacuation individually. Each participant was required to take part in a single evacuation only. In order to add a degree of pressure on the participant to evacuate as quickly as possible, three 'stooge' passengers were also seated in the cabin during the evacuations. The 'stooge' passengers were seated in seats adjacent to the passenger, and on the call to evacuate released their seatbelts and moved towards the exit. As with previous studies reported in this paper, participants were recruited via local and regional advertising. The same insurance and medical requirements applied, and the same restrictions were therefore enforced.

4.3. Experimental design

There was one independent variable in the research study, the Type III exit design. For forty participants the Type III exit was configured as a conventional "plug" style hatch. The hatch was modified for the other forty trials into an "up-and-over" automatically disposed hatch.

The dependent variable was elapsed time from the call to evacuate, which was "Undo your seatbelts and get out!". The evacuation time for each participant was the elapsed time from the call to evacuate until the point where the participant had both feet on the wing. The exit availability time for each participant was the time take from the call to evacuate until the exit was available for egress.

4.4. Procedure

On arrival at the test session, participants were issued with a bib detailing their volunteer number, and were also provided with a clipboard containing the paperwork for the trials. The height and weight of all participants was measured and documented by the research team. Each participant completed a medical questionnaire, which was checked and signed by the evacuation first aider.

Participants were then briefed with regards to the nature of the trials, health and safety considerations including the emergency stop procedure, and payment details.

On completion of the briefing, the participant boarded the cabin simulator, with the 'stooge' passengers. All participants sat in the seat adjacent to the Type III exit. Once the participant was seated, the member of cabin crew provided a safety briefing which included the location of the exits, and demonstrations of the use of seatbelts and oxygen masks. In addition, the participant received an individual briefing on their emergency duties, which included the instruction that they were not to open the exit unless a member of cabin crew instructed them to do so. When the safety briefings were complete, a pre-recorded evacuation scenario was then played. This included a period of engine noise, followed by an announcement from the Captain to "Undo your seat belts and get out!".

At this point, the cabin crew member, who was located at the front of the cabin, commanded the passenger to open the Type III exit. The passenger was urged to move quickly throughout the evacuation. The cabin crew member used assertive, concise, positive commands, in accordance with the findings of Muir & Cobbett (1996). A number of stewards were located outside the exit, in order that evacuating passengers could be moved swiftly away. The evacuation was deemed complete when the passenger had evacuated the cabin. The participant was then asked to complete a post-evacuation questionnaire. On completion of the questionnaires, the participant was thanked, debriefed and paid.

4.5. Results

A total of 75 participants took part in the testing programme. 53 were male (70.7%) and 22 were female (29.3%). It is noted that one participant did not answer the demographic questionnaire. Participants provided their age at the time of the testing session. Participants' ages ranged from 21 to 46 years, with a mean age of 27.5 years, and a standard deviation of 5.6 years. 6 participants were left handed (8.0%) and 68 were right handed (90.7%). Most participants had flown previously on a commercial flight (72 participants, or 96.0%), and no participants reported having to make an emergency evacuation.

In total, seventy five evacuations were conducted. Thirty seven were conducted in the conventional hatch configuration, and thirty eight were conducted in the modified up and over configuration. There were no reported injuries.

The video footage was edited and time coded. All timings were taken from the Captain's command to "Undo your seatbelts and get out!". Egress times for each participant was extracted from the time coded footage. These timings were taken from the call to evacuate until the point where each participant had both feet upon the wing. The time taken for the participant to operate the Type III exit and make it available for egress was also extracted from the video footage.

4.5.1. Evacuation times

Mean evacuation times for the participants within each condition are given in Table 11. These times include Type III exit operation times.

Table 11: Mean evacuation times (in seconds) for participants to egress through the Type III exit in each condition.

Exit design	
Conventional hatch	**Up and over hatch**
13.5 (sd 4.0)	8.6 (sd 2.6)

As can be seen in Table 11, the evacuation times vary by test condition. In order to assess the statistical significance of these differences, an independent t-test was conducted on the data. The results are shown in Table 12. Again, it should be noted that this analysis includes the time taken to make the Type III exit available for evacuation.

Table 12: t-test results for participants to evacuate through the Type III exit, by hatch type

		Levene's test for equality of variances		t-test for equality of means		
		F	**Sig**	**t**	**df**	**Sig**
Egress time	Equal variances assumed	7.45	0.00	6.23	73	0.00
	Equal variances not assumed			6.20	61.62	0.00

The results in Table 12 indicate that there were statistically significant differences in the time taken to evacuate between hatch type conditions. The mean times demonstrate that participants evacuated significantly faster in the automatically disposed hatch condition than they did in evacuations with the conventional hatch design.

4.5.2. Exit availability time

In order to examine the effects of hatch type on the time taken to make the Type III exit available, these data were analysed separately. The time taken to make the exit available was defined as the time taken from the call to evacuate, until the exit was available for evacuation. The means for each condition are shown in Table 13.

Table 13: Mean exit availability time (in seconds) in each condition

Exit design	
Conventional hatch	**Up and over hatch**
12.2 (sd 4.3)	5.8 (sd 2.1)

As can be seen in Table 13, the time taken to make the exit available for evacuation varies by test condition. In order to assess the statistical significance of these differences, an independent t- was conducted on the data. The results are shown in Table 14.

Table 14: t-test results for participants to make the Type III exit available for evacuation, by hatch type.

		Levene's test for equality of variances		t-test for equality of means		
		F	**Sig**	**t**	**df**	**Sig**
Egress time	**Equal variances assumed**	16.91	0.00	8.31	73	0.00
	Equal variances not assumed			8.24	51.19	0.00

The results in Table 14 indicate that there were statistically significant differences in the time taken for participants to make the exit available for evacuation, due to the type of hatch. The means indicate that participants were able to make the exit available more quickly in evacuations where the hatch had an automatic disposal mechanism than when it was a conventional "plug" style design.

5. Discussion

The studies undertaken were all conducted to examine the operation and use of the Type III exit in 2x2 cabin configurations, where there are two seats each side of a main aisle. Much of the work that has been conducted on Type III exits has examined passenger evacuations from aircraft with 3x3 cabin configuration, that is, configurations with three seats either side of the main aisle. It must be noted that all of the results reported here relate to preliminary experimental work; there is insufficient data for any firm conclusions to be drawn. Nevertheless, the results do raise some interesting issues regarding Type III exits in smaller airframes.

The first study investigated the use of the Type III exit in small group evacuations, with up to 20 participants. The Type III exit was a conventional hatch design, and the cabin seating was arranged so that there was either a 10 or 13″ vertically projected passageway at the Type III exit. Tests were conducted in both the 2x2 and the 3x3 configuration. The results indicated that there was a significant effect for cabin configuration, such that evacuations in the 2x2 configuration were significantly faster than evacuations in the 3x3 configuration. However, there was no effect for vertical projection, indicating that there was no difference between evacuation times obtained with 10″ or 13″ vertically projected passageways for evacuations conducted under this condition. These differences were evident in the overall evacuation times for the first 15 participants to evacuate; there were no effects at all for the time it took to make the Type III exit available.

The second study examined a modification to the Type III exit operating handle. The handle on a conventional Type III hatch generally retracts after operation, moving back into the recess. The modification made for this experiment fixed this operating handle once it had been pulled, so that, in effect, the lever became a second, fixed handle or handhold. Tests were conducted in both the 2x2 and the 3x3 configurations. Although each participant operated the exit twice; once in each condition under either the 2x2 or the 3x3 cabin configurations, only the data from naïve participants has been included in this analysis. The results showed that there was a significant effect for cabin configuration on evacuation times, such that overall, evacuations in the 3x3 cabin configuration were quicker than those in the 2x2 configuration.

It is not clear why this might be the case, since the findings directly contradict the results obtained in the first study. However, it may be that this is a function of the number of people in the cabin. In the first study, upwards of fifteen people evacuated, and the 2x2 configuration produced the fastest evacuations. It may be that the shortened passageway length associated with the 2x2 configuration offset the lack of headroom available for evacuating passengers. However, with only one person evacuating, the additional length of passageway in the 3x3 configuration is not really a factor. For the second experiment, individual participants in the 3x3 tests would have benefited from the additional headroom relative to those who took part in evacuations from the 2x2 configuration.

With regards to the operation of the Type III exit itself, it appears that the modification made to the Type III exit in the second experiment had no effect on the time it took to operate the Type III exit. It had been expected that the alteration to the operating handle, to fix the mechanism so that it could function as a second handle or handhold, would reduce the time taken to operate the exit hatch. In fact, there was no discernable effect of the modification.

This may be an effect of the in-depth briefing that was provided to passengers at the Type III exit, in which the cabin crew explained fully the exit operation task. However, there was a significant effect for the cabin configuration, such that participants were able to make the exit available more quickly in the 3x3 configuration. This supports the suggestion above, that in these individual tests, participants were able to benefit from the additional headroom in the 3x3 trials, relative to participants in the 2x2 trials.

Again, it must be stressed that these results are from a limited number of trials. However, it does seem clear that having a Type III exit in an aircraft with a 2x2 configuration does not significantly reduce the overall evacuation time compared to the 3x3 configuration. However, it would also appear that the lack of headroom in a 2x2 configuration, relative to a 3x3 configuration, increases the time taken to make the Type III exit available. While it is true that regional jets would have a lower passenger count, this may indicate that any regulations specific to automatic hatch disposal could also generalise to aircraft with 2x2 seating arrangements. With regards to the passageway length, it would appear that the reduction in the length of the passageway in a 2x2 configuration may compensate somewhat for the reduced headroom, at least when groups of passengers are evacuating. Further trials may be necessary to explore this effect. It must also be acknowledged that passengers are best able to open the Type III exit when they have been adequately prepared to do so, and therefore the briefing provided to passengers has a significant role in determining the outcome of the exit operation task.

6. References

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