

# An evaluation of the comprehensibility of graphical exit signs for passenger aircraft Phases 1 & 2

F.J.Joel Morley  
Ann M.Cobbett

COA report No.9706  
April 1997

Human Factors Technology Group  
College of Aeronautics  
Cranfield University  
Cranfield  
Bedford MK43 0AL  
England



1403691666

COA report No.9706  
April 1997



# An evaluation of the comprehensibility of graphical exit signs for passenger aircraft Phases 1 & 2

F.J.Joel Morley  
Ann M.Cobbett



Cranfield Information and Library Service  
Cranfield University  
Bedford MK43 0AL  
(01234) 754444

This work			tdienst (RLD),
The			ngoing
"7			ne and
			"
Hun			
Coll			
Crai			
Crai			
Bed			
England			

### **Executive Summary**

1. The purpose of this report is to present the results of a two phased study which aimed to evaluate the comprehensibility of a number of graphical exit signs for use in passenger aircraft. It is thought that the use of graphical symbols to depict this information has the advantages of being universally comprehensible without dependence on language, while requiring less space to display the signs than using multiple languages.
2. The results of phase 1 and phase 2 are presented. Phase 1 involved the evaluation of seven graphical signs indicating three meanings: the actual location of an exit, exits located to the left and right, and that the emergency exit(s) was/were located further down the aircraft aisle (straight ahead). The second phase involved the evaluation of three graphical signs (with the same three meanings) in addition to an evaluation of the comprehensibility of their language based equivalents.
3. An analysis of the comprehensibility of the graphical signs revealed the variants evaluated which indicated the location of the exit were sufficiently understood by members of the traveling public to be put into use. Comprehension of the current language based sign was significantly higher than the best graphical sign for this meaning.
4. The graphical signs evaluated which indicated that exits are located to the left and right were also sufficiently understood by the traveling public. Comprehension of the current language based sign was significantly lower than that of the best graphical sign for this meaning.
5. The graphical signs evaluated which indicated that the exits are located further down the aisle using upwards facing arrows failed to meet the comprehension criteria. The current language based sign also failed to meet the criteria. However comprehension of the best graphical sign was found to be significantly higher than the current language based sign and as such is an improvement to what is currently used.
6. Specific conclusions related to these signs, and general conclusions regarding the use of graphical symbols to convey this type of information are presented.

## Contents

	Page
1.0 Introduction	1
2.0 Testing Program - Phase One	2
2.1 Participants	2
2.2 Procedure	3
2.3 Results - Phase One	4
2.4 Meaning 1: The actual location of the emergency exit	6
2.5 Meaning 2: The exits are located to the left and right	7
2.6 Meaning 3: The exit(s) is/are located further down the aircraft aisle	7
2.7 Intervening variables	8
2.8 Conclusions from Phase One	11
3.0 Testing Program - Phase Two	13
3.1 Results - Phase Two	13
3.2 Meaning 1: The actual location of the emergency exit	15
3.3 Meaning 2: The exits are located to the left and right	15
3.4 Meaning 3: The exit(s) is/are located further down the aircraft aisle	15
3.5 Intervening variables	16
3.6 Conclusions from Phase Two	19
4.0 Overall Conclusions	20

### List of Annexes:

- A Graphical signs used in the evaluation
- B Photographs used to demonstrate the signs to participants
- C Typical exit signage location in an aircraft cabin; conclusions from Phases One & Two (used with permission of Aerospatiale 1996)

Note: Although the signs and the photographs used to demonstrate the signs in the study were presented in colour, they are shown here in black and white to facilitate reproduction.



## 1.0 Introduction

In response to the difficulties reported by a number of manufacturers of regional/commuter aircraft in indicating the route to emergency exits in more than one language, the JAA's Cabin Safety Study Group (CSSG) funded by Rijksluchtvaartdienst (RLD), undertook to investigate the possibility of alternative means of indicating the location of exits, specifically through the use of internationally recognized symbols. These have been referred to throughout the course of this project as "graphical exit signs" since they use pictures or symbols to convey meaning. The overall purpose of this research was to evaluate the comprehensibility of these types of signs in light of proposed changes to JAR 25.811 and JAR 25.812.

A need was identified for four different types of signs pursuant to JAR 25.811 (d):

- signs indicating the actual location of an emergency exit known as 'exit marking sign' in [JAR 25.811 (d) (2)];
- signs indicating that an emergency exit is located in one direction (left or right) known as 'exit locator sign' in [JAR 25.811 (d) (1)];
- signs indicating that emergency exits are located in both directions (left and right), and [JAR 25.811 (d) (1)];
- signs indicating that the emergency exit(s) is/are located further down the aircraft aisle (straight ahead) known as 'sign on each bulkhead or divider that prevents fore and aft vision along the passenger cabin to indicate emergency exits beyond and obscured by the bulkhead or divider' in [JAR 25.811 (d) (3)].

The process of identification of alternate means of depicting the routes to exits was undertaken by the Aerospatiale Centre de Competence Technique on behalf of the Cabin Safety Study Group. After researching current standards (ISO 3864, EC Directive 92/58) for exit signs in various contexts (e.g. buildings), a number of alternative graphical exit signs were developed. The program of research was conducted in two phases. For the purpose of this report the two phases will be treated as separate investigations. The initial phase involved the evaluation of seven graphical signs indicating three meanings: the actual location of an exit, exits located to the left and right, and that the emergency exit(s) was/were located further down the aircraft aisle (straight ahead). The second phase involved the evaluation of three graphical exit signs (with the same three meanings) in addition to an evaluation of the comprehensibility of their language based equivalents. The testing in both phases took place at Schiphol Airport, Amsterdam, Netherlands and was carried out by the Mobiel centre witnessed by Cranfield University.

## 2.0 Testing Program - Phase One

The signs evaluated in phase 1 of the testing program were selected on the basis of their differences. Three variables were specifically selected for investigation: the method of depicting the actual exit, the number of figures and arrows depicted, and the types (directions) of arrows used. The seven signs evaluated were identified as 1a, 1b, 2a, 2b, 3a, 3b, and 3c and can be found at Annex A. Two signs indicated the location of an exit (1a and 1b), two signs indicated that exits were located to the left and right (2a and 2b) and three signs indicated that the emergency exit(s) was/were located further down the aircraft aisle(straight ahead) (3a, 3b, and 3c).

The case described above where the signs indicate that an exit is located in one direction only was dropped from the study due to the similarity between that case and the case where an exit is located in both directions. As the only difference between the two signs is the number of arrows, results from the two direction case should be generalisable to the one direction case.

The next step in the research was to determine how easily the signs could be understood by the population who would be required to interpret the signs in an emergency egress from an aircraft - members of the flying public. Accordingly, a method to evaluate the comprehensibility of the signs was developed at the Human Factors Group, College of Aeronautics, Cranfield University.

The methodology was based upon the Comprehension Test, laid out in the International Standards Organization's (ISO) "Procedures for the development and testing of public information symbols" (ISO 9186). The research consisted of a questionnaire which was interviewer administered to members of the traveling public in a busy international airport.

## 2.1 Participants

Participants were selected to take part in the study by targeting departing flights bound for different regions of the world. The logic behind this procedure was that the proposed signs would be placed aboard aircraft which would be dispatched to all corners of the globe and carry individuals of countless nationalities. As such, it was necessary to ensure that the signs could be understood by travelers of various backgrounds. The intended sample is represented in Table 1.

**Table 1**      **Intended sample of respondents by region**

Region	Intended Sample
Western Europe	50%
Eastern Europe	5%
North America	15%
Asia	10%
Africa	5%
Latin America	10%
Middle East	5%
Oceania (Australia and N.Z.)	0%

## 2.2 Procedure

A questionnaire was administered to each participant by one of a team of interviewers employed by Mobiel Centre. For the most part, the questionnaires were interview administered, meaning that the questions were posed verbally and the answers were recorded by the interviewer. However, in certain cases, the interviewers were unable to speak the language in which the questionnaire was being administered. In these instances, the questionnaires were read and completed by the respondent. The languages in which the questionnaires were interview administered were Dutch, English, German, French, Italian, and Spanish. The self completion method was employed for questionnaires in Russian, Japanese, Arabic, Portuguese, Korean and Turkish. The wording of all instructions and questions was equivalent for all questionnaires

Regardless of the method used to complete the questionnaire, a similar procedure was employed for each participant. The interviewers were assigned to outgoing flights by the Mobiel Centre Supervisor. They then proceeded to the boarding area for these flights and asked a random selection of passengers waiting to board that flight to participate in the research. Passengers who agreed to participate were then provided with an introduction to the study and a set of instructions, either verbally or in writing depending upon the method of questionnaire administration. Following this, each participant was shown three signs (one variant for each meaning) in an order which had been randomized to prevent practice effects. The signs shown to the participants were placed in context aboard an aircraft by using photographs of the signs as they would be displayed. The interviewers were instructed to point to the sign within the photograph to draw the participant's attention to it. Copies of the photographs used to demonstrate the signs are shown at Annex B.

Participants were asked to answer two questions for each sign. The first consisted of completing the statement: "This sign indicates that..." and the second was "Have you ever seen this sign before?" The answer to the first question was recorded in, as much as possible, the exact words of the participant and was meant to be the initial interpretation of the meaning of the sign in that the participants were not intended to have time to think about their answer. The underlying logic here is that the signs are intended to assist with an emergency egress from an aircraft and as such require an immediate and accurate interpretation. The answer to the second question consisted simply of yes or no.

Following this, each participant was asked to provide some demographic information to aid with the interpretation of the results. The information requested was: age, gender, nationality, country of residence, first language, other languages, number of times per year the participant travels abroad, the number of times per year the participant travels by air, and whether the passenger was transferring aircraft or starting or finishing their flight at Schiphol at the time.

Participants were thanked for their cooperation, and the questionnaires were retained by Mobiel Centre for translation and partial coding of results. The responses to the open ended questions were translated into English and collated by sign and participant number before being returned to Cranfield University. Similarly, the responses to the other questions were translated, coded and returned to Cranfield for analysis.

The open ended responses were then coded according to the methodology set out in ISO 9186. A panel of three independent judges (all post-graduate students at Cranfield University) were recruited and each one individually coded the responses on a seven point scale. The three judges then went through a process of consultation to ensure that the responses had been equivalently coded. Where any disagreement existed between the coding of a particular response, this was resolved by discussion until all three judges agreed upon the coding of that response. The categories used are set out in table 2 below. For the purposes of coding, correct understanding was defined as interpreting the signs according to the meanings set out in section 1.0. The judges assessed the responses using the following criteria: “Based on the answer provided, would the individual be able to locate the exit in the case of an emergency.”

**Table 2 Coding categories for open ended responses.**

Rating	
1	Correct understanding of the symbol is <b>certain</b>
2	Correct understanding of the symbol is <b>likely</b>
3	Correct understanding of the symbol is <b>marginally likely</b>
4	The meaning which is stated is <b>opposite to that intended</b>
5	The response is <b>wrong</b>
6	The response given is “ <b>don’t know</b> ”
7	No response is given

### 2.3 Results - Phase 1

In total, 695 people participated in phase 1 of the research. The participants ranged in age from 10 to 75 years (mean age 39.6). The sample was 74% male and 26% female. The high proportion of male participants is most likely due to a high proportion of air travelers being male since the participants were selected by chance from outgoing flights.

The regional make up of the final sample is represented in table 1 along with the intended sample. The figures for the intended sample were determined based upon traffic at Schiphol Airport, and relevance to JAA countries. The heavy concentration on Western Europe was intended to ensure that passengers of different aircraft types and categories would be included in the study. This sampling strategy ensured that a wide variety of cultural backgrounds were represented in the final sample. This cultural diversity is reflected in the fact that 61 different first languages were reported by the participants.

**Table 3 Proportion of respondents by region (actual versus intended)**

Region	Final Sample	Intended Sample
Western Europe	50.1%	50%
Eastern Europe	6.3%	5%
North America	14.9%	15%
Asia	11.4%	10%
Africa	7.1%	5%
Latin America	4.2%	10%
Middle East	4.5%	5%
Oceania (Australia and N.Z.)	1.6%	0%

Of the 695 participants, 54% of those interviewed were in the process of transferring from one flight to another, and 46% were either starting or ending their journey in Amsterdam. The mean number of trips taken abroad per year by the participants was 10.1, and the mean number of times participants traveled by air per year was 10.6.

The distribution of responses (expressed as a percentage of the sample responding to that sign) for the various signs is reported in table 3, along with the proportion of respondents (%) who reported that they had seen the sign before.

**Table 4 Proportion of responses in each category by sign and proportion of respondents reporting previous exposure to sign.**

Response	1a	1b	2a	2b	3a	3b	3c
1	63.4	60.0	68.8	65.4	24.0	39.5	41.7
2	12.7	13.1	14.7	15.7	13.4	18.0	15.7
3	5.8	8.9	8.2	8.4	23.5	17.4	16.3
4	0.5	0.0	0.6	0.9	3.9	2.9	1.5
5	10.6	12.8	5.4	8.4	27.9	17.4	18.4
6	6.9	5.2	2.3	1.2	7.3	4.7	6.3
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
proportion having seen previously	41.5	35.1	34.1	46.9	33.1	49.1	30.7

Of interest here is the low proportion of the sample who had come in contact with the signs before the study. Despite variants of the signs being in common use throughout parts of Europe, and the research taking place in a major European airport, less than 50% of respondents reported having seen the signs before. The two possible explanations for this are that the majority of respondents had in fact not seen the signs before as approximately 50% of respondents were of non-Western European origin, or that the respondents had seen the signs before but had taken little notice of them and as such reported that they had not seen the signs previously. Regardless of the actual explanation, what is of more interest is the proportion of the respondents who could be classified as correctly interpreting the symbols.

A comprehension score (the proportion of respondents whose answers were classified as being either certain or likely to be correct) was calculated for each of the signs tested. ISO 9186 states that this figure should be at least 66%, although it should be

significantly higher for symbols conveying safety critical information. The results of this test are presented in Table 4.

**Table 5 Results of the comprehensibility test by sign.**

Sign	Meaning	Comprehension Score	Acceptable (>66%)
1a	Actual location of emergency exit	76.1%	Yes
1b		73.1%	Yes
2a	Emergency exits are located in both directions	83.6%	Yes
2b		81.0%	Yes
3a	Emergency exit(s) located further down aisle	37.4%	No
3b		57.6%	No
3c		57.4%	No

These results indicate that, according to the guidelines set out in ISO 9186, two of the three different meanings are correctly interpreted by an acceptable proportion of the population to be considered comprehensible. However, three of the variants (3a, 3b, 3c) all have comprehensibility scores below the requisite 66%. Therefore, the signs achieve their aim in indicating the emergency exit and in indicating that exits are located to either direction, but fail to convey the meaning that the exits are located further down the aircraft aisle. At this point, we shall turn our attention to an examination of the different variants of the signs with equivalent meanings.

#### **2.4 Meaning 1: The actual location of the emergency exit (sign 1a, 1b).**

As can be seen from table 4, the actual differences between the comprehensibility score for signs 1a and 1b are, in real terms, actually quite small (3%). The two signs differ in the way they depict the exit, or door, and the location of the person in relation to the door. Sign 1a, which has a slightly higher comprehensibility rating, depicts the door by a white square, and the person approaching it. Sign 1b also depicts the door as a white square but shows the person in the doorway itself.. The difference in comprehension rates is small enough, however, that we may conclude that either sign would be acceptable for use. However, the symbol used should be consistent with other symbols in use throughout the aircraft. As such, the results of the examinations of signs 2 and 3 should be considered before making a decision with respect to this sign.

In conducting the coding of the responses, it was noticed that some participants inferred meaning from the direction that the person on the sign was facing. Answers included, move to the left, or to the right for the exit despite the fact that a door was shown in the picture directly below the sign. As such, the depiction of a person moving in one direction should be paid particular attention. It is possible that comprehension rates for sign 1a for example could be increased if a person were depicted on either side of the door facing inwards (i.e. two people depicted, both facing the door from different directions).

## **2.5 Meaning 2: The exits are located to the left and right (sign 2a, 2b)**

Referring back to table 4 once again, there is a very small difference between the rates of comprehension for signs 2a and 2b. However, sign 2a does score slightly better (2.6%). The two signs differed in terms of the number of doors and people depicted and the location of the arrows on the sign with sign 2a being a more true to life depiction of the actual situation. Two people are shown, one facing in each direction, there are two arrows, and the doors are depicted outboard of the people. Given that it was observed that people infer meaning from all parts of the sign, and the fact that this sign had a slightly higher rate of comprehension, we must conclude that this sign is the preferable option to indicate that exits are located in both directions since it is less likely to be misunderstood than sign 2b.

## **2.6 Meaning 3: The exit(s) is/are located further down the aircraft aisle**

Two things are evident from the comprehensibility ratings in table 4 with respect to the comprehensibility of signs 3a, 3b and 3c. First, all three signs fail to meet the 66% comprehensibility criterion set out by ISO 9186, and second, sign 3a achieves a noticeably lower comprehensibility score than sign 3b or 3c.

One possible explanation for the lower rates of comprehension found for this sign is the fact that there are fewer contextual cues found in the area of this sign to inform the participant that the sign indicates an emergency exit. The photographs used to demonstrate signs 1a and 1b showed the sign located above a door, a cue which helped quite a few participants infer the meaning to the sign. Similarly, the photographs used to demonstrate signs 2a and 2b showed a bulkhead with a gap indicative of an aircraft doorway (see Annex B). However, the photographs for signs 3a and 3b had no such cues to indicate the presence of an exit. As such, it is likely that contextual cues are critical to the correct interpretation of these types of signs.

The three signs differed only in the type and direction of arrows used to depict the location of the exit. Sign 3a used two dimensional arrows facing downwards to depict straight ahead, sign 3b used two dimensional arrows facing upwards to depict straight ahead, and sign 3c used three dimensional arrows facing upwards to depict straight ahead.

The arrows which faced downwards (sign 3a) achieved the lowest comprehensibility score. Incorrect responses to this question showed that respondents were often interpreting the arrows to mean that they should proceed downwards by means of stairs and even trap doors in the floor. As such, it should be noted that downward facing arrows are not an appropriate means for indicating that people should continue straight ahead.

The arrows which faced upwards (signs 3b and 3c) achieved significantly better comprehensibility scores, although there was no appreciable difference in the scores (0.2%) for the two variants. As such, upwards facing arrows are more appropriate to indicate that people should proceed straight ahead. However, the addition of a three dimensional depiction of the arrow does not improve the comprehensibility of the sign.

Notwithstanding the fact that signs 3b and 3c scored appreciably better than sign 3a, none of the three variants actually meet the set cut off score of 66% comprehensibility. This is probably due to a lack of contextual cues as discussed earlier and some confusion as to the meaning with the arrows. Although more participants correctly interpreted the upwards facing arrows as meaning proceed straight ahead than the downward facing arrows, there were still quite a few participants who interpreted these arrows to mean that they had to move upwards by some means. Looking back to our discussions of signs 2a and 2b, it is possible that these difficulties may be rectified by modifying the sign to make it as true to life as possible. For example, the depiction of the doors on the sign could represent the actual location of the doors in the aircraft and the arrows could indicate that the exit is further down the aisle then to the left or right (i.e. an arrow which points upwards then bends to indicate left or right). Also, the depiction of the figure could be modified to indicate that the person is proceeding down the aisle. These modifications could allow participants to construct a more accurate cognitive picture of the real situation from looking at the sign and as such may compensate for the lack of contextual cues associated with the location of this sign.

Although the above recommendations are aimed at improving the comprehensibility of the signs to indicate that an exit is located further down the aisle, it should also be noted that the signs evaluated (particularly 3b and 3c) would most likely achieve a higher comprehensibility score than the signs currently in use, were the current signs to be subjected to a similar evaluation to that used here, given the current sign's reliance on written language. As such, while these signs do not meet the minimum comprehensibility score set out for the purposes of this evaluation, they are probably an improvement on the existing standard.

## **2.7 Intervening variables**

Having discussed the overall comprehensibility of the signs, we must now turn our attention to an examination of the variables which may influence comprehensibility. The purpose of this part of the research was to ensure that a person's ability to understand the meaning of the sign would not be dependent upon their demographic characteristics.

Three variables were of particular interest here. The first, nationality or region, is important since the signs are to be placed aboard passenger aircraft which will travel throughout the world and carry people of many nationalities. Participants in this study represented 74 different nationalities which were then classified into eight different regions. The regional distribution of the sample is included at Table 3. The second, previous exposure, is important since the signs should be able to be correctly interpreted by anyone without having to have seen the sign before. The third, frequency of air travel, is of interest since it will serve to ascertain to what degree familiarity with the aircraft environment helps in interpreting the signs.

For the purposes of the analysis, a mean comprehensibility score was calculated which represents the proportion of signs demonstrated which were correctly interpreted by a given participant. This was accomplished by taking the mean of the comprehension scores for all three signs demonstrated. The mean comprehensibility scores range from 0



to 100% where 100% represents all of the signs being correctly interpreted and 0% represents all of the signs being incorrectly interpreted. As such, this variable serves as an indicator of how easily a person understands the graphical exit signs in general and does not imply understanding of any particular sign. The mean values of this score broken down by region are presented in Table 6 below.

**Table 6 Mean comprehensibility scores by region (expressed as a percentage of signs correctly interpreted)**

Region	Mean (%)	Standard Deviation
Western Europe	78.45	24.40
Eastern Europe	55.30	32.90
North America	72.81	27.51
Asia	62.29	30.61
Africa	39.71	36.54
Latin America	61.49	33.07
Middle East	57.78	34.94
Oceania (Australia and New Zealand)	66.66	29.81

The effect of nationality on one's ability to correctly interpret the meaning of the signs was analysed using a One-way Analysis of Variance (ANOVA) procedure. This test compares the results obtained against the expected results if the two variables were unrelated using a distribution of the F statistic. The probability indicated in table 7 below indicates the likelihood of this degree of relationship between the variables occurring strictly by chance. The lower the number, the less likely the relationship occurred by chance. The main effect for region was highly significant ( $F_{7,677}=16.1060$ ,  $p<.001$ ) meaning that a participant's region is a good predictor of comprehensibility of the sign. The results of the analysis of variance are shown in Table 7.

**Table 7 One-way ANOVA table for region by mean comprehension**

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Probability
Between Groups	7	8.9232	1.2747	16.1060	.0000
Within Groups	677	53.5825	.0791		
Total	684	62.5057			

These analyses show that a participant's region of origin plays a significant part in determining one's ability to understand the signs. A Tukey Honestly Significant Difference (Tukey HSD) post hoc test was conducted in order to determine the origins of the significant effect. In other words, we wish to determine which regions were significantly different from others in terms of mean comprehension. This test revealed two different groups in terms of comprehension with Western Europe, North America and Oceania differing significantly from the other regions. An examination of the means presented in Table 7 reveals that participants from these regions score significantly better in interpreting the meaning of the graphical exit signs. Possible explanations for these differences are discussed in section 2.8.

In order to gain a better understanding of comprehension across Europe, the analysis of comprehension in this region was broken down further. Given the small numbers of

participants from some countries, four sub-groups were used for the analysis. These were: countries of Latin background (France, Italy, Spain and Portugal); English speaking countries (most likely to understand the current signs) (United Kingdom); The Netherlands (selected due to the large numbers of participants), and Multi-lingual countries (Belgium and Switzerland). A One-way Analysis of Variance (ANOVA) was conducted in order to determine whether differences existed with respect to mean comprehension across these regions. The results, located in Table 8 show no significant differences across these regions. Therefore, people with different linguistic and cultural backgrounds within Europe are equally able to interpret the meaning of the signs.

**Table 8 One-way ANOVA table for European region by mean comprehension**

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Probability
Between Groups	3	3316.86	1105.62	1.95	.1213
Within Groups	262	148228.93	565.76		
Total	265	151545.79			

The second variable of interest, previous exposure to the signs, was assessed for each sign individually using chi-square tests for goodness of fit. These tests compare the obtained results against the expected results for the variables of interest. In the case at hand, comprehension scores were compared to the responses for the question "Have you ever seen this sign before?" The results of these tests indicate that previous exposure was only moderately associated with comprehension for only one out of the seven signs. Comprehension scores for sign 1a versus previous exposure ( $\chi^2_1=3.97$ ,  $p<.05$ ) reached moderate statistical significance, indicating that previous exposure improved comprehension in this case. However, all of the other signs failed to reach significance. The actual chi-square statistics for all seven signs are shown in Table 9. The significance column of this table denotes the probability of this relationship happening purely by chance. In general, a result is considered significant only if the probability of it occurring by chance is close to zero (i.e. significance  $<.05$  = moderate significance, significance  $<.01$  = highly significant). Therefore, the results shown in Table 9 indicate that, with the exception of sign 1a, the relationship found between comprehension and previous exposure is attributable to chance and not to a relationship between the two variables. These results are not surprising considering the relatively low proportion of respondents who reported having seen the signs before noted earlier. Therefore, it may be concluded that an individual's ability to correctly interpret the signs is not dependent upon having seen the signs before.

**Table 9 Chi-square statistics for comprehension versus previous exposure**

Sign	$\chi^2$	Degrees of Freedom	Significance
1a	3.97	1	.04624
1b	3.52	1	.06048
2a	0.30	1	.58136
2b	0.01	1	.93960
3a	0.82	1	.36568
3b	0.00	1	1.00000
3c	0.45	1	.49793

The final variable of interest, frequency of travel, was also examined relative to mean comprehension of the symbols. For the purposes of the analysis, the sample was divided into four groups (low frequency travelers, low-medium frequency travelers, medium-high frequency travelers and high frequency travelers) by calculating the quartiles of the number of times per year participants traveled by air. A One-way ANOVA was then used to examine the effect of frequency of air travel on one's ability to understand the signs. As depicted in the results shown in Table 10, here was a significant main effect for travel on comprehension ( $F_{3, 679} = 11.40, p > .001$ ). A Tukey HSD post-hoc test revealed that medium-high and high frequency travelers demonstrated significantly greater comprehension than the other two groups. The means and standard deviations of comprehension for the four groups are presented in Table 11.

**Table 10 One-way ANOVA table for travel by mean comprehension.**

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	Probability
Between Groups	3	29740.36	9913.45	11.40	.0000
Within Groups	679	590426.59	869.55		
Total	682	620166.95			

**Table 11 Mean Comprehension by frequency of travel**

Frequency of Air Travel	Mean	Standard Deviation
Low	61.69	31.94
Low-medium	67.95	31.82
Medium-high	76.38	27.46
High	76.49	25.55

These results indicate that higher frequency of air travel enhances one's ability to correctly interpret the signs. It is hypothesized that greater frequency of air travel means that individuals are more familiar with the aircraft environment and as such are more readily able to interpret the signs in that context.

## 2.8 Conclusions from Phase One

In sum, the signs evaluated met the comprehensibility criteria for two of the three meanings for which the signs were intended. The signs designed to show the actual

location of the exit (1a and 1b) differed only slightly in comprehensibility ratings with sign 1a scoring slightly better.

The signs intended to indicate that exits were located in two directions, again, differed only slightly in terms of comprehensibility with sign 2a scoring slightly better. This was attributed to the fact that sign 2a provided a more realistic picture of the actual situation than sign 2b through the addition of an additional figure and door symbol.

The signs intended to indicate that exits were located further down the aisle (3a, 3b, and 3c) all failed to achieve the required level of comprehension. Sign 3a, with arrows pointing downwards, was significantly lower in comprehension rates than signs 3b or 3c which used upwards facing arrows. Signs 3a and 3b are close to achieving the required level of comprehension and the reason why they failed to achieve 66% comprehension is hypothesized to be the lack of contextual cues surrounding the sign. It is suggested that the provision of more information, to make the sign a close approximation of the actual situation, may increase the level of comprehension. The use of three dimensional arrows did not have an impact of the comprehensibility rating of the sign.

Participant's region of origin proved to be significantly associated with comprehension with participants of Western European, North American or Oceanic origin demonstrating higher comprehension rates. This difference is difficult to explain, but may be of some significance in implementing the use of the signs in other parts of the world. It is possible that this difference is partially due to the constraints of the situation under which the signs were evaluated in that the languages in which questionnaires for Eastern Europe, Asia, the Middle East and Latin America were to be administered necessitated self administration of the questionnaires. A lack of interviewer prompting could have led to less complete answers which would have led to lower comprehension scores.

This explanation is supported by the fact that previous exposure to the symbols did not significantly increase understanding. One would expect Europeans to be more familiar with symbols of this type as they are in use in many European countries at present. However, the fact that previous exposure was generally unrelated to comprehension is encouraging in that it means that Europeans are probably no more familiar with the signs than others, and more importantly, that one does not have to have had previous exposure to the signs to be able to interpret them correctly.

One's origins within Europe did not prove to be significantly related to comprehension. However, it was found that frequency of air travel was. It was hypothesized that greater familiarity with the aircraft environment allowed easier interpretation of the contextual cues surrounding the signs. This finding has significant implications with respect to introducing the symbols to the flying public.

### 3.0 Testing Program - Phase Two

Following the recommendations of phase 1 a new graphical sign was designed by the Aerospatiale Centre de Competence Technique on behalf of the Cabin Safety Study Group to illustrate that the exit(s) is/are located further down the aircraft aisle (sign 3d in Annex A). In order to test respondent's comprehension of this new sign the same methodology and procedures employed in phase 1 were used in phase two. Participants were shown three signs in a counterbalanced order (one variant for each of the three meanings). The signs selected for inclusion were those with the highest comprehension scores in phase 1, illustrating the actual location of the emergency exit (1a) and emergency exits are located in both directions (2a) and the new sign illustrating emergency exit(s) located further down the aircraft aisle (3d).

In order that a comparison could be made between respondent's level of comprehension of the graphical signs and their equivalent language sign half of the respondents were shown three language signs (one for each meaning, denoted as 1e, 2e and 3e in Annex A).

### 3.1 Results - Phase Two

In total, 670 people participated in this phase of the study; 365 answered questions pertaining to the graphical signs, 305 pertaining to the language signs. The graphical signs sample was 68% male with a mean age of 39.8 years. The language signs sample was 62% male with a mean age of 40 years.

The regional make up of the final samples is represented in Table 12 along with the intended sample. The sampling strategy employed in phase 1 was again used in phase 2. This strategy ensured that a wide variety of cultural backgrounds were represented in the sample. Forty One different first languages were reported by the respondents.

**Table 12 Proportion of respondents by region**

Region	Graphical sign sample	Language sign sample	Intended sample
Western Europe	52%	55%	50%
Eastern Europe	7%	7%	5%
North America	14%	14%	15%
Asia	8%	10%	10%
Africa	8%	5%	5%
Latin America	5%	4%	10%
Middle East	5%	4%	5%
Oceania (Australia/N.Z)	2%	2%	0%

Of the 365 participants who answered questions pertaining to the graphical signs, 59% of those interviewed were in the process of transferring from one flight to another and 41% were either starting or ending their journey in Amsterdam. The mean number of

trips taken abroad was 8.02 and the mean number of times participants traveled by air per year was 9.13

Of the 305 participants who answered questions pertaining to the language signs, 61% of those interviewed were in the process of transferring from one flight to another and 39% were either starting or ending their journey in Amsterdam. The mean number of trips taken abroad was 9.26 and the mean number of times participants traveled by air per year was 10.6

The distribution of responses (expressed as a percentage of the sample responding to that sign) for the various signs is reported in Table 13, along with the proportion of respondents reporting previous exposure to the sign.

**Table 13 Proportion of responses in each category by sign a proportion of respondents reporting previous exposure to the sign.**

- 1 = Actual location of the emergency exit  
 2 = Emergency exits are located in both directions  
 3 = Emergency exit(s) located further down the aircraft aisle

Response	Graphical			Language		
	1a	2a	3d	1e	2e	3e
1 correct understanding is certain	45.5	55.9	25.2	37.4	65.9	35.4
2 correct understanding is likely	36.7	27.1	19.2	58	8.2	5.9
3 correct understanding is marginally likely	7.1	7.9	24.9	1	12.1	27.2
4 response is the opposite to that intended	0.3	0	4.7	0.3	4.6	22.6
5 The response is wrong	7.7	6.8	16.7	3	8.2	7.5
6 "Don't Know"	2.7	2.2	9.3	0.3	1	1.3
7 No response is given	0	0	0	0	0	0
Proportion having seen previously	34.8	30.1	18.4	75.1	76.1	72.5

The low proportion of participants reporting that they had previously seen the graphical signs replicated the findings of Phase 1. It has been suggested that either the majority of respondents had in fact not seen the signs before as approximately 50% of respondents were of non-Western European origin, or that the respondents had seen the signs before but had taken little notice of them and as such reported that they had not seen the signs previously. A significantly higher proportion of the sample reported having seen the language based signs before. This may have been as a result of the context in which the question; "have you seen this sign before?" was asked. As respondents were asked this question after the presentation of the sign which depicted the interior of an aircraft, they may have responded to it with this context in mind. As language based signs are currently used on board aircraft this may have led to the higher proportion of respondents reporting previously seeing them.

A comprehension score (the proportion of respondents whose answers were classified as being either certain or likely to be correct) was calculated for each of the signs tested. ISO 9186 states that this figure should be at least 66%, although it should be significantly higher for symbols conveying safety critical information. Table 14 shows the results of this test.

**Table 14 Results of the comprehensibility test by sign**

Sign	Meaning	Comprehension score	Acceptable (>66%)
1a - Graphical	Actual location of emergency exit	82.2%	Yes
1e - Language	"	95.4%	Yes
2a - Graphical	Emergency exits are located in both directions	83%	Yes
2e - Language	"	74.1%	Yes
3d - Graphical	Emergency exit(s) located further down aisle	44.4%	No
3e - Language	"	41.3%	No

Phase 1:

<i>3b - Graphical</i>	"	57.6%	No
-----------------------	---	-------	----

These results indicate that, according to the guidelines set out in ISO 9186, two of the three different meanings are correctly interpreted by an acceptable proportion of the population. However, both the graphical and language based signs tested in phase 2 (3d and 3e) indicating that the emergency exit(s) are located further down the aisle failed to reach the requisite 66%. Annex c presents these results graphically and indicates the typical exit signage locations in an aircraft cabin.

### 3.2 Meaning 1: The actual location of the exit

As can be seen from table 14, both the language and graphical signs are acceptable. The comprehension of the language based sign, however, is significantly higher than the comprehension of the graphical equivalent ( $\chi^2_1=26.65$ ,  $p<0.0001$ ). The participants who incorrectly comprehended the graphical signs appeared to ignore contextual cues in the photograph (i.e. the exit itself) or tried to explain how to open the door rather than interpret the meaning of the sign.

### 3.3 Meaning 2: The exits are located to the left and the right

As can be seen from table 14, both the language and graphical signs are acceptable. The comprehension of the graphical sign however is significantly higher than the comprehension of the language equivalent ( $\chi^2_1=7.42$ ,  $p=0.006$ ). It would appear that this higher comprehension rate is as a result of the fact that the graphical sign more closely depicted the real world and was therefore more easily understood.

### 3.4 Meaning 3: The emergency exit(s) is/are located further down the aisle

Both the graphical and language signs fail to meet the 66% comprehensibility criterion set out by ISO 9186. Although there was a slightly higher comprehension rate of the graphical sign this difference was not significant. When assessing the graphical sign many participants appeared to comprehend the idea of movement but failed to identify this with the existence or location of the exit. Many of the respondents who were shown the language sign interpreted correctly that an exit was nearby but failed to understand that they would have to move to locate the exit. This was perhaps due to the lack of arrows on the language based sign. The lack of contextual cues such as a bulkhead with

a gap indicative of an aircraft doorway meant that photographs for signs 3d and 3e did not have contextual cues to indicate the presence of the exit. Such cues are critical to the correct interpretation of both graphical and language signs and may have led to the lower comprehension rates for these signs.

Table 14 also shows the comprehension rate of the highest comprehended sign with this meaning used in phase 1. The comprehension of the graphical sign used in phase 1 (3b) was significantly higher than the graphical sign tested in phase 2 (3d) ( $\chi^2_1=7.98$ ,  $p<0.005$ ). Furthermore the comprehension of the graphical sign used in phase 1 (3b) was significantly greater than the comprehension of its language equivalent (3e) ( $\chi^2_1=11.43$ ,  $p<0.0007$ ). Therefore, of the signs tested, to depict this meaning, a graphical sign (3b) demonstrates the greatest comprehension despite failing to meet the 66% cut off score.

### **3.5 Intervening variables**

Having discussed the overall comprehensibility of the signs assessed in phase 2 an assessment of the variables which may influence respondents comprehensibility was made. The purpose of this was to ensure that a person's ability to understand the meaning of the sign would not be dependent upon their demographic characteristics.

Four variables were of particular interest. The first, nationality, is important since the graphical signs are to be placed aboard passenger aircraft which will travel throughout the world carrying people of many nationalities. Indeed respondents nationality in phase one was found to influence their comprehension of the graphical signs. The second, was to investigate the influence of previous exposure to the signs, since it is important that the signs can be understood without having seen them before. The third, frequency of air travel, is of interest since it will highlight the degree of influence that familiarity with the airline environment has on one's ability to interpret the signs. The fourth, the influence of the language spoken by participants on interpretation of the signs is of particular interest with the language based signs.

For the purpose of the analysis and consistency with phase 1, a mean comprehensibility score was calculated which represents the proportion of signs demonstrated which were correctly interpreted by a given participant. This was accomplished by taking the mean of the comprehension scores for all three signs demonstrated. The mean comprehensibility scores range from 0 to 100% where 100% represents all of the signs being correctly interpreted and 0% represents all of the signs being incorrectly interpreted. As such, this variable serves as an indicator of how easily a person understands the exit signs (graphical or language) in general and does not imply understanding of any particular sign. The mean values of this score broken down by region are shown in Table 15 below.



**Table 15** Mean comprehensibility scores by region (expressed as a percentage of signs correctly interpreted)

Region	Graphical Signs			Language Signs		
	Respondent No.	Mean (%)	SD	Respondent No.	Mean (%)	SD
Western Europe	188	72.16	24.84	167	73.05	25.33
Eastern Europe	24	62.50	34.49	22	69.69	25.06
North America	52	70.51	28.50	44	75.00	27.95
Asia	29	70.12	22.44	29	59.77	28.70
Africa	30	56.66	27.88	14	69.04	24.33
Latin America	17	82.35	23.91	12	61.11	23.92
Middle East	19	68.42	34.19	11	54.54	26.96
Oceania	6	55.55	34.42	6	61.11	13.61

SD - Standard Deviation

The effect of nationality on one's ability to correctly interpret the meaning of the signs was analysed using a factorial Analysis of Variance (ANOVA) procedure. The main effect of region on the comprehension of all of the signs was mildly significant ( $f_{7,654}=1.978$ ,  $p<0.05$ ). This result suggests that overall comprehension of all of the signs presented was influenced by respondents region of origin. However the 2-way interaction of a participant's region of origin and types of sign they were shown (either graphical or language) was found to be non significant ( $f_{7,654}=1.798$ ,  $p<0.09$ ). Thus the overall effect of region was not attributable to difficulties in interpreting one particular type of sign (either graphical or language).

The second variable of interest, previous exposure to the signs, was assessed for each sign individually using chi-square tests for goodness of fit. These tests compare the obtained results against the expected results for the variables of interest. In the case at hand, comprehension scores were compared to the responses for the question "Have you ever seen this sign before?" The results of these tests indicate that previous exposure was only moderately associated with comprehension for only one out of the seven signs. Comprehension scores for sign 1b versus previous exposure ( $\chi^2_1=3.92$ ,  $p<0.05$ ) reached moderate statistical significance, indicating that previous exposure improved comprehension in this case. However, all of the other signs failed to reach significance. The actual chi-square statistics for all six signs are shown in Table 16. The results shown in Table 16 indicate that, with the exception of sign 1b, the relationship found between comprehension and previous exposure is attributable to chance and not to a relationship between the two variables. The fact that previous exposure did not influence participant's comprehension of the graphical signs is not surprising considering the relatively low proportion of respondents who reported having seen these signs before. It can therefore be concluded that an individual's ability to correctly interpret these signs is not dependent upon having seen the signs before. Interestingly the only language based sign which was influenced by participants previous exposure was the sign indicating the actual location of the exit. Although a high proportion of respondents reported seeing the other two language based signs before (2e and 3e) it would appear that the lack of contextual cues in the photographs and the fact that these signs failed to resemble the real world led to fewer respondents correctly interpreting them.

**Table 16 Chi-square statistics for comprehension versus previous exposure**

Sign	$\chi^2$	Degrees of Freedom	Significance
1a	1.93	1	0.17
1e	3.92	1	0.047
2a	1.97	1	0.16
2e	0.43	1	0.51
3d	0.37	1	0.54
3e	0.016	1	0.89

The third variable of interest, frequency of travel, was also examined relative to mean comprehension of the symbols. For the purposes of the analysis, the sample was divided into four groups (low frequency travelers, low-medium frequency travelers, medium-high frequency travelers and high frequency travelers) by calculating the quartiles of the number of times per year participants traveled by air. A factorial ANOVA was then used to examine the effect of frequency of air travel on one's ability to understand the signs. The mean comprehension level for the four groups is shown in Table 17. Frequency of travel did not have an influence on comprehension of either the graphical or language based signs ( $F_{3, 661} = 1.81, p > 0.144$ ).

**Table 17 Mean Comprehension by frequency of travel**

Frequency of Air Travel	Language signs		Graphical signs	
	Mean	Standard Deviation	Mean	Standard Deviation
Low	68.93%	25.31	68.40%	29.47
Low-medium	66.67%	25.95	64.04%	27.27
Medium-high	73.26%	26.86	70.83%	27.04
High	70.43%	27.06	74.56%	21.68

The final intervening variable of interest was the influence of an individual's first language being English on their comprehension of either type of sign (graphical or language based). Table 18 shows the mean comprehension of those individuals whose first language was English and for those whose first language was not English for both types of signs.

**Table 18 Influence of English as a first language on mean comprehension**

English as a first language	Language Signs	SD	Graphical Signs	SD
No	67.81%	24.84	69.42%	28.02
Yes	75.25%	28.15	70.73%	25.46

A factorial ANOVA was used to examine the effect of English as a first language. The analysis showed a mildly significant result ( $F_{2, 666} = 3.982, p = 0.046$ ) suggesting that if you spoke English as a first language you would have a slightly higher comprehension level of the signs you were shown. It would appear that this trend was slightly stronger with respondents who were shown the language based signs.

### 3.6 Conclusions from Phase Two

In conclusion, both the graphical and language based signs evaluated met the comprehensibility criteria for two of the three meanings for which the signs were intended. The signs showing the actual location of an exit are sufficiently understood with significantly more participants comprehending the language based sign. The participants who incorrectly comprehended the graphical signs appeared to ignore contextual cues in the photograph (i.e. the exit itself) or tried to explain how to open the door rather than interpret the meaning of the sign.

The graphical and language based signs depicting exits to the left and right are sufficiently understood. However significantly more participants comprehended the graphical sign. It would appear that this higher comprehension rate is as a result of the fact that the graphical sign more closely depicted the real world and was therefore more easily interpreted.

The graphical and language based signs tested in phase 2 depicting exit(s) further down the aisles did not reach the 66% comprehension criteria. However the graphical sign from phase 1 (sign 3b) has significantly greater comprehension than the language equivalent. Therefore of the signs tested to depict this meaning, graphical sign (3b) demonstrates the greatest comprehension despite failing to meet the 66% cut off score.

Participant's region of origin was found overall to mildly influence comprehension of all of the signs. However this effect was not attributable to difficulties in interpreting one particular form of the signs (either graphical or language).

Previous exposure to either the graphical or language based signs did not significantly increase understanding. The fact that previous exposure did not influence participant's comprehension of the graphical signs is not surprising considering the relatively low proportion of participants who reported having seen these signs before. The non significant result is encouraging suggesting that one does not have to have had previous exposure to the signs to be able to interpret them properly.

Frequency of air travel did not prove to be significantly related to comprehension. However participant's who spoke English as a first language were found to have a higher overall comprehension score. Whilst this trend was slightly stronger with the language based signs, the influence of participants first language did not differ significantly between the graphical and language based signs.

## 4.0 Overall Conclusions

A number of specific conclusions may be drawn.

- The graphical signs evaluated which indicate the location of the exit are sufficiently understood by members of the traveling public to be put into use. Comprehension of the current language based sign was significantly higher than the best graphical sign.
- The graphical signs evaluated which indicate that exits are located to the left and right are also sufficiently understood by the traveling public. Comprehension of the current language based sign was significantly lower than that of the best graphical sign.
- The graphical signs evaluated which indicate that the exits are located further down the aisle using upwards facing arrows failed to meet the comprehension criteria. The current language based sign also failed to meet the criteria. However comprehension of the best graphical sign was found to be significantly higher than the current language based sign and as such is an improvement to what is currently used.

Also a number of general conclusions may be drawn based upon the preceding analyses.

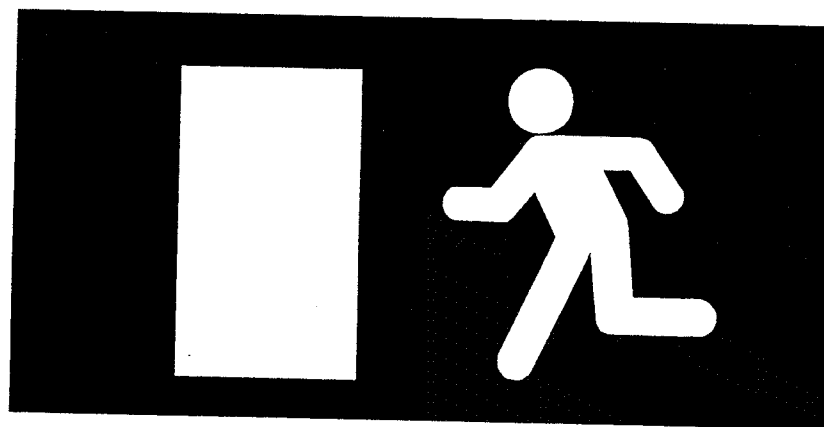
- People infer meaning from all parts of the sign;
- The more closely a sign resembles the actual situation (e.g. depicting two doors where two doors exist), the more readily it will be understood, and the less likely it will be of being misunderstood.
- One's region of origin may be a factor in how an individual comprehends the signs.
- Previous exposure to the signs is not significantly related to one's ability to correctly interpret the meaning of the sign.
- Familiarity with the aircraft environment may assist in interpreting the meaning of the signs.
- One's first language may be related to one's ability to interpret the meaning of both graphical and language based signs.

## **References**

- Aerospace Industries Association (1985). Standards for Symbology and Graphic Signage Aboard Commercial Aircraft. Document number TARC 82-29. TARC Project 211-1.
- Guillard, S. (1995). Quelle Norme Pour Baliser les Degagements. Face au Risque, 313, Mai, 41-43.
- International Organization for Standardization (1995). Safety Identification - Safety Colours and Safety Signs (Proposal for a revised version) ISO 3864 (Part 1). Geneva: International Organization for Standardization.
- International Organization for Standardization (1989). Procedures for the development and testing of public information symbols. ISO 9186: 1989E. Geneva: International Organization for Standardization.

## Annex A: Graphical signs used in the evaluation

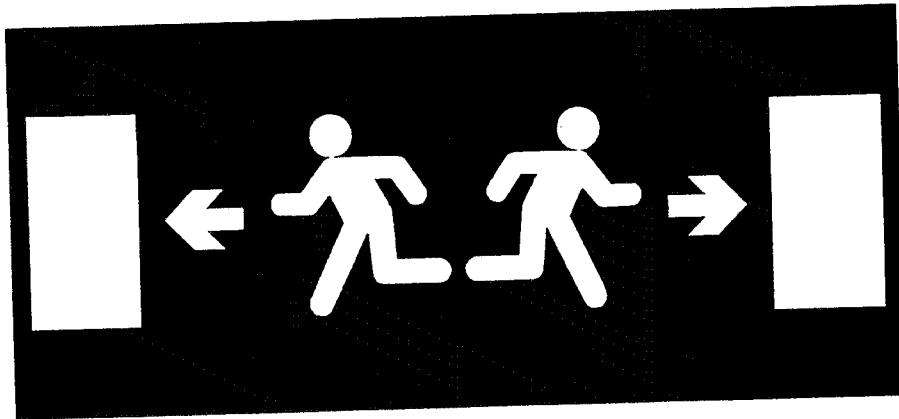
Sign	Meaning
1a	Actual location of emergency exit
1b	Actual location of emergency exit
2a	Emergency exits are located in both directions
2b	Emergency exits are located in both directions
3a	Emergency exit(s) located further down aisle
3b	Emergency exit(s) located further down aisle
3c	Emergency exit(s) located further down aisle
3d	Emergency exit(s) located further down aisle



1a



1b

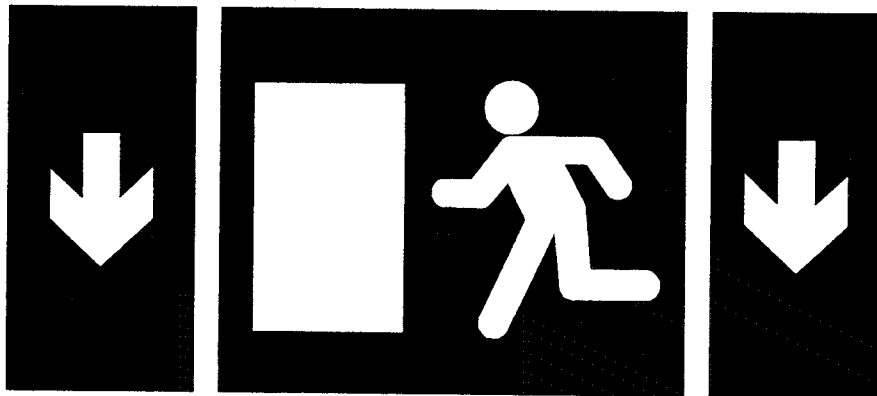


2a

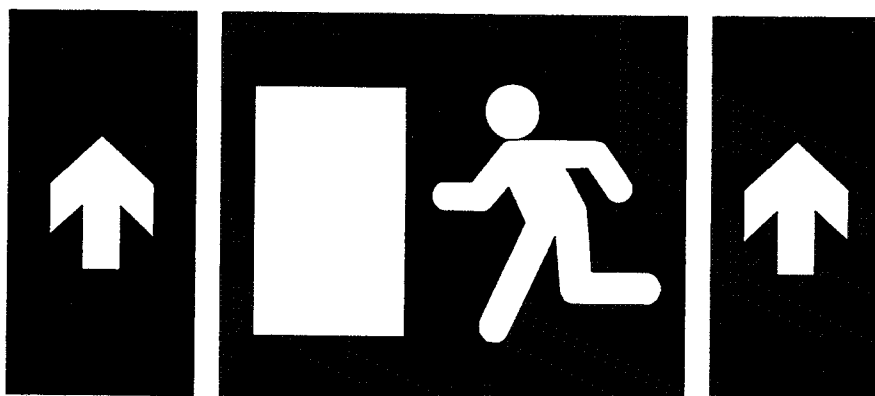


2b

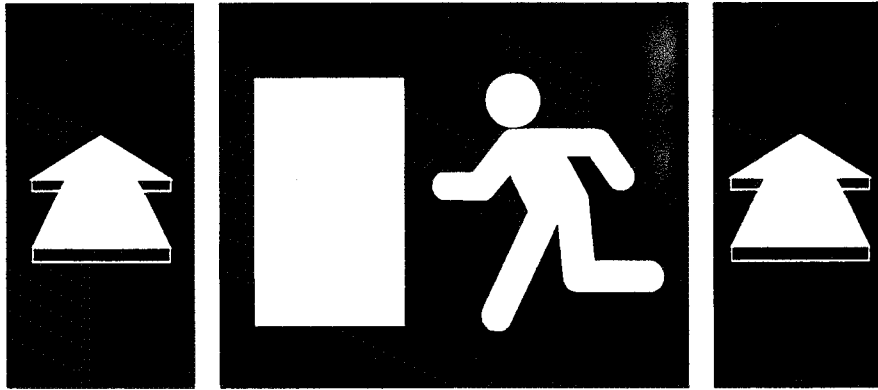




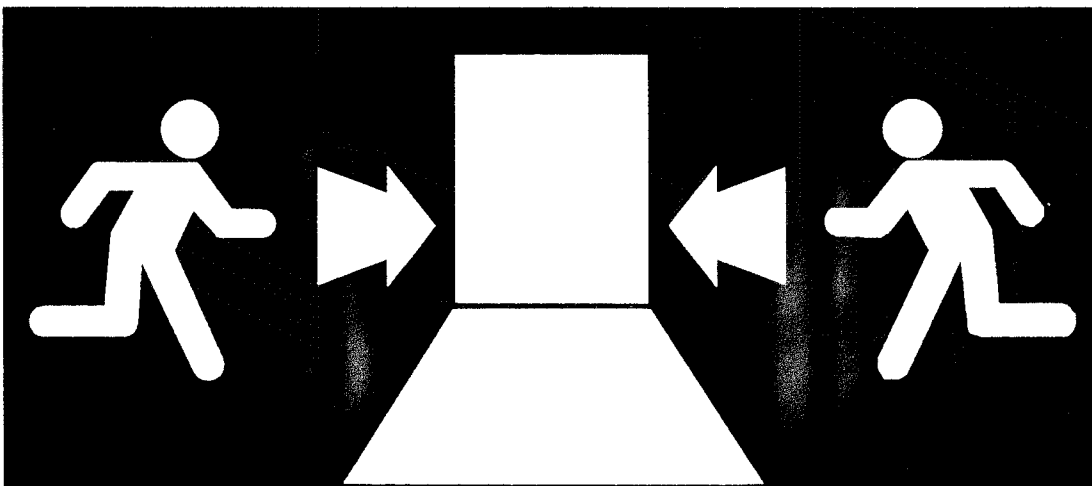
3a



3b



3c

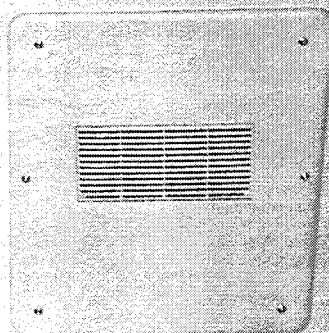
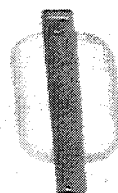
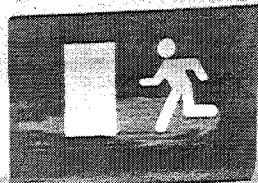


3d

**Annex B: Photographs used to demonstrate signs to participants**

Fasten curtain during  
Take off and landing

Fissare la tenda durante  
il decollo e l'atterraggio.

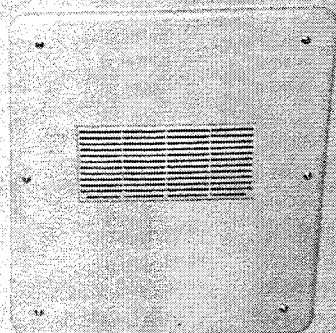
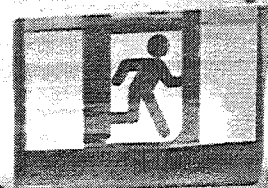


APERTO  
OPEN

EXIT

Fasten curtain during  
Take off and landing

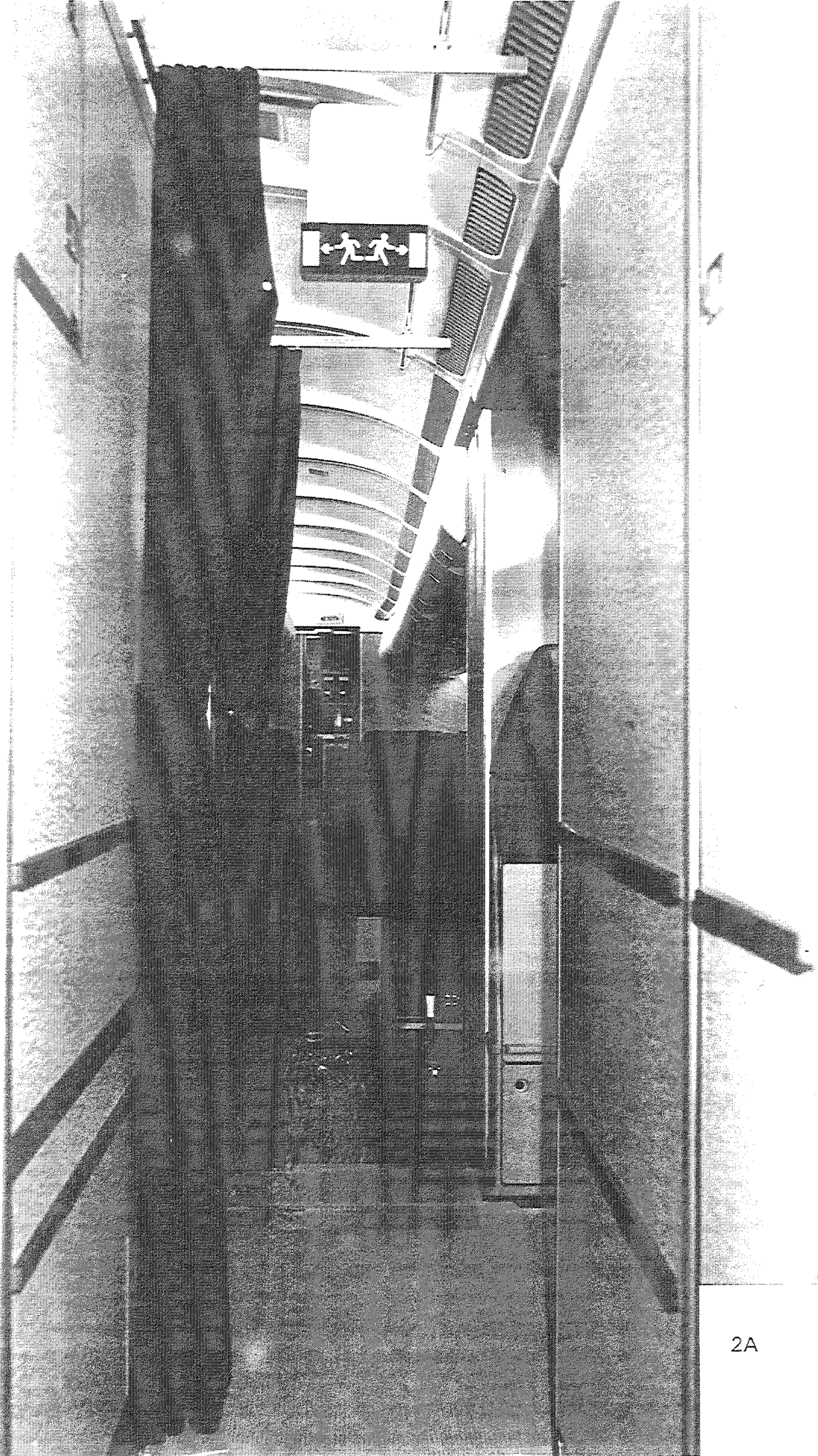
fissare la tenda durante  
il decollo e l'atterraggio

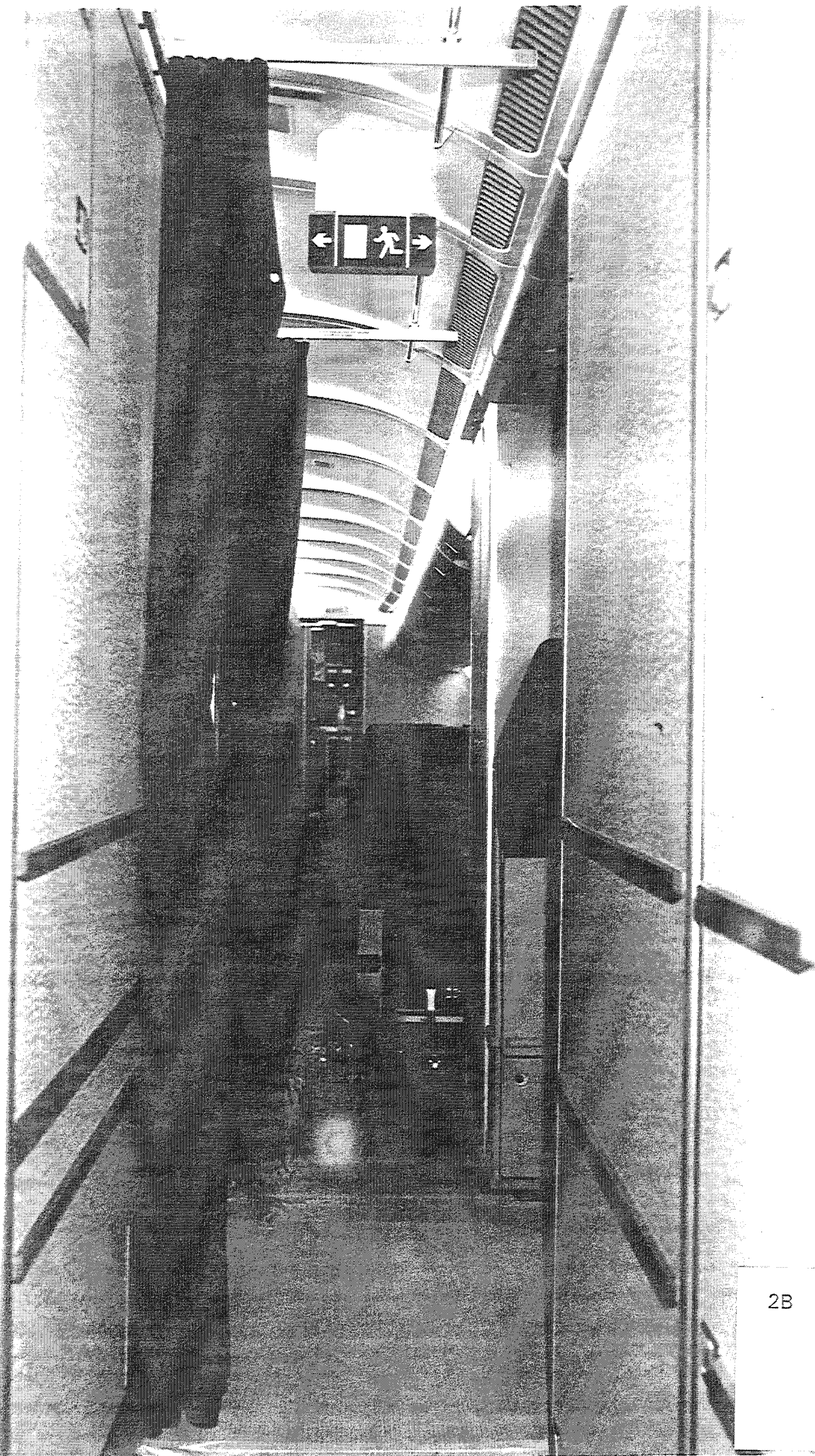


APERTO  
OPEN

EXIT

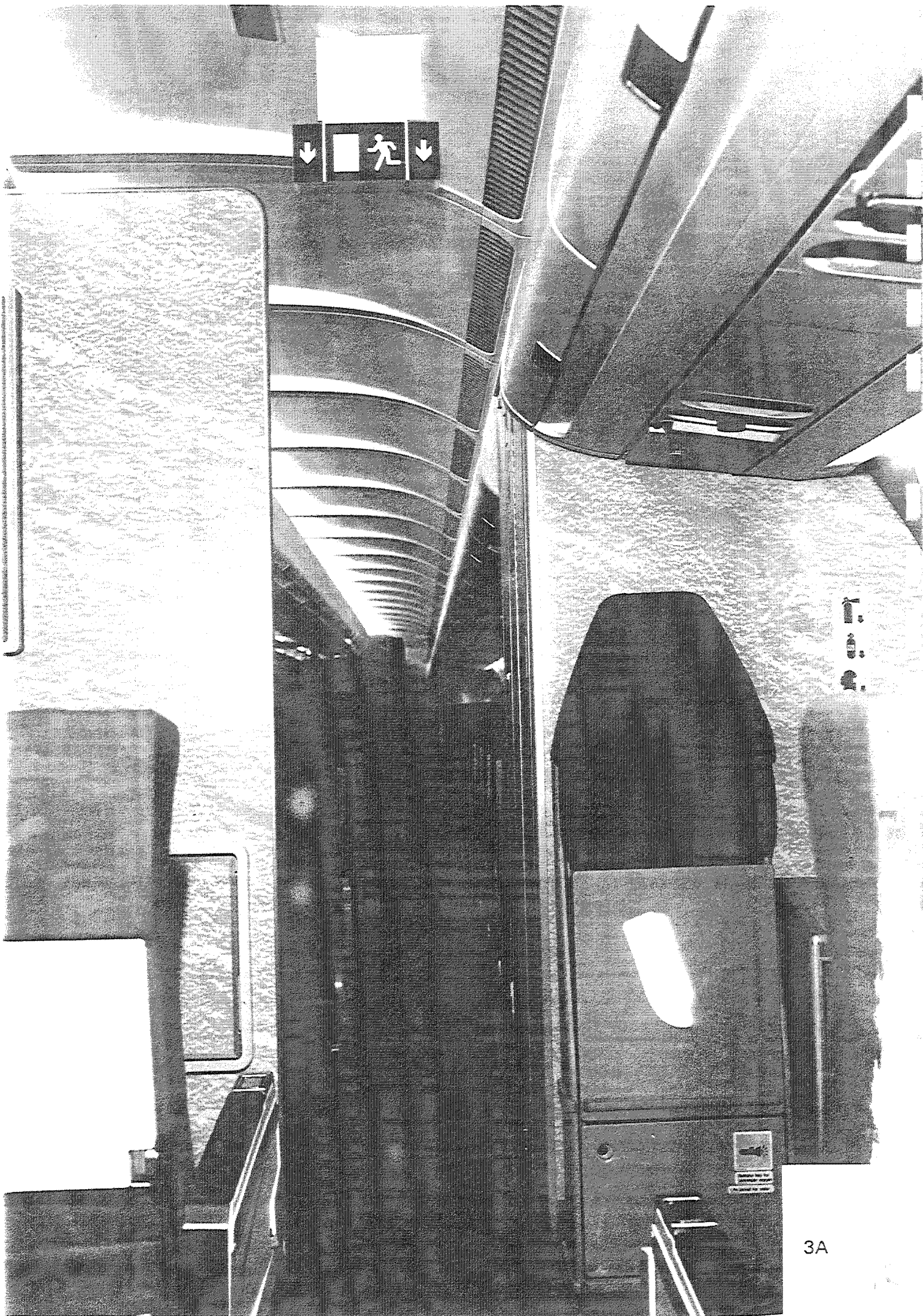




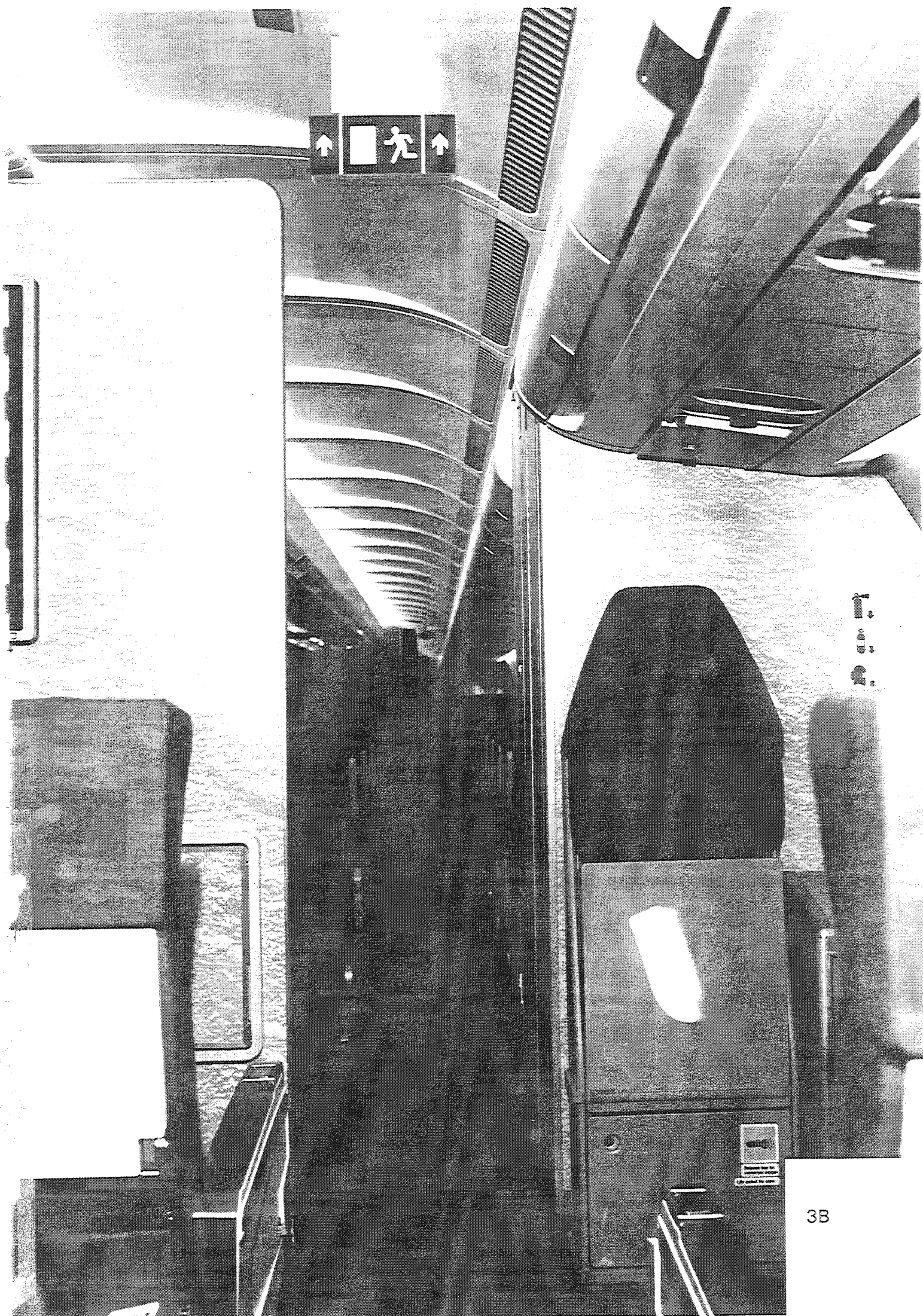


2B

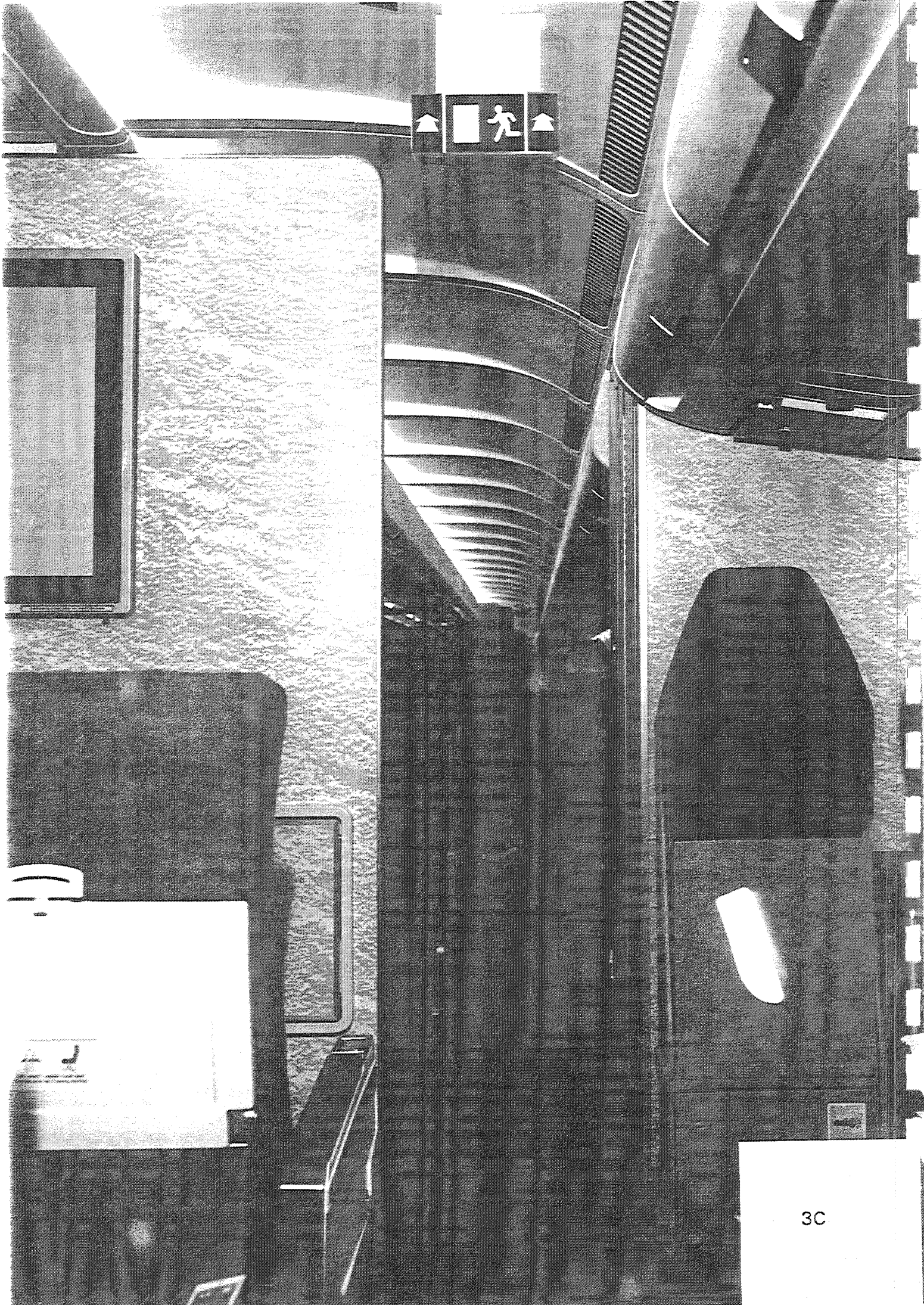












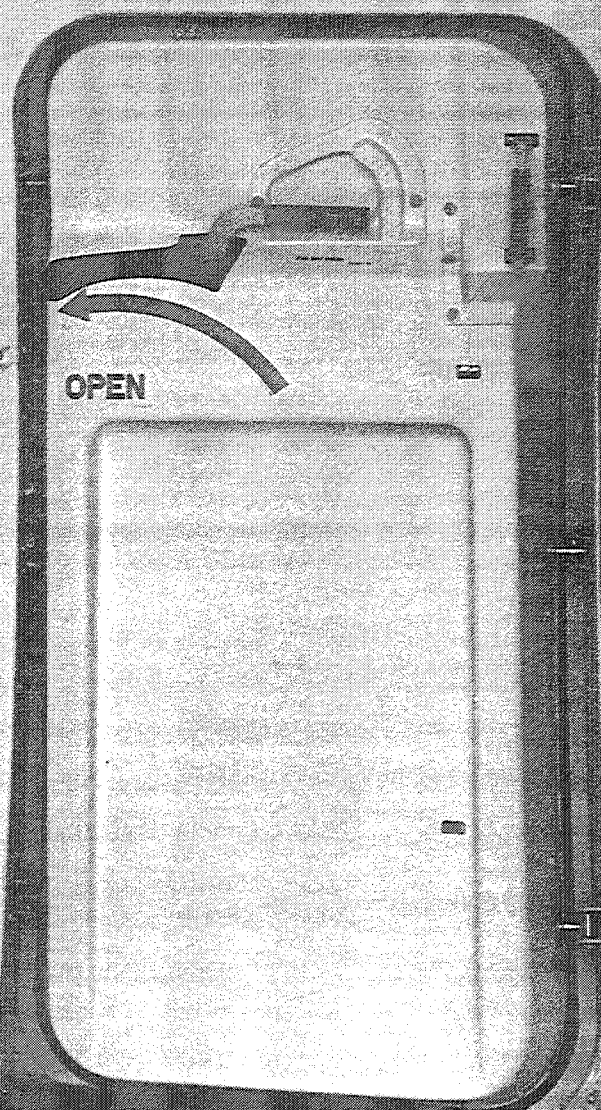






Fasten seatbelts during  
take off and landing

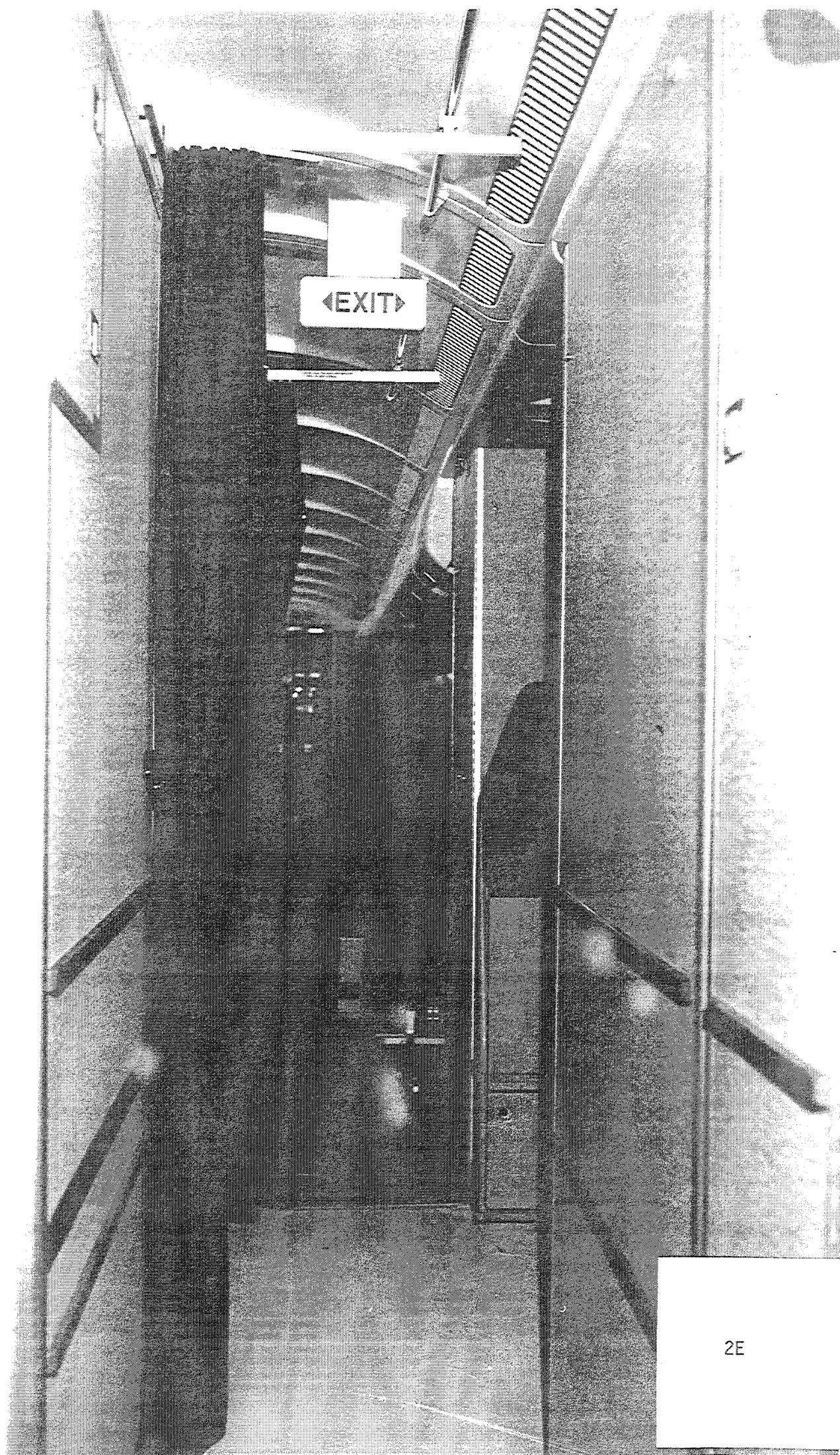
0 000 000 0 0 0



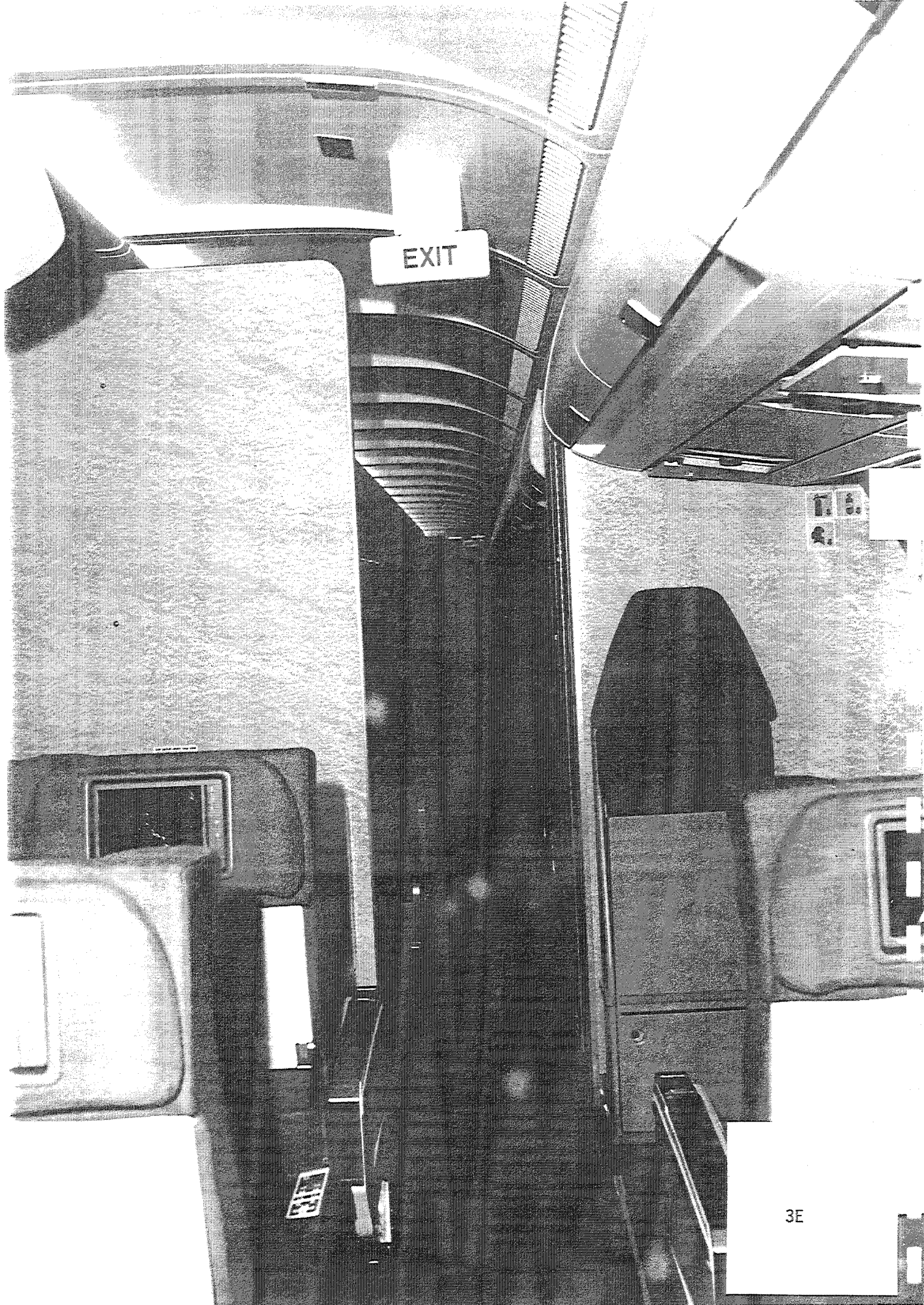
OPEN

EXIT









**Annex C: Typical exit signage locations in an aircraft cabin; conclusions from  
Phases One and Two**

# CONCLUSIONS FROM PHASE 1 AND 2



(2b) 81% > 66% acceptable alternatives to

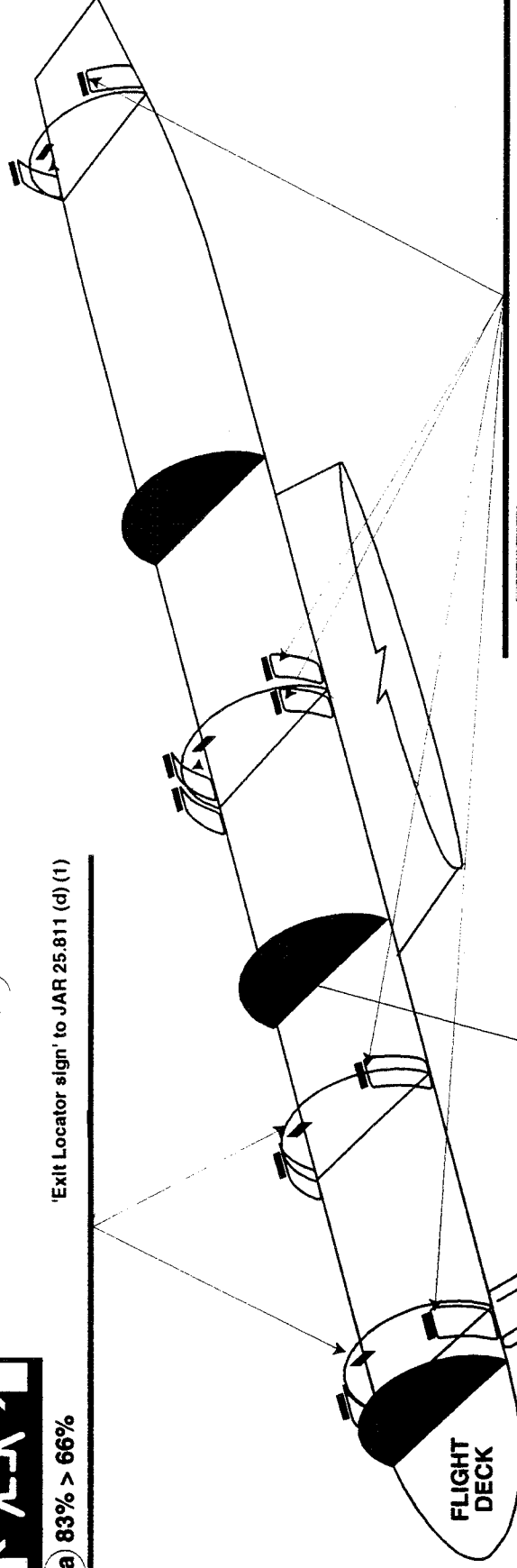
◀EXIT▶

(2e) 74%



(2a) 83% > 66%

'Exit Locator sign' to JAR 25.811 (d) (1)



(1b) 73% > 66% acceptable alternatives to

EXIT

(1e) 95%



(1a) 76-82% > 66%



(3b) 57,6% < 66%

Improvement to

EXIT

(3e) 41%

'Exit sign at bulkhead / divider' to JAR 25.811 (d) (3)

'Exit Marking sign' to JAR 25.811 (d) (2)

## GENERAL CABIN LAY-OUT