CRANFIELD UNIVERSITY

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THE EFFECT OF CABIN CREW BEHAVIOUR UPON THE COMPETITIVE EVACUATION OF PASSENGERS FROM A NARROW-BODIED AIRCRAFT

DEPARTMENT OF APPLIED PSYCHOLOGY
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M.Sc. THESIS

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ACADEMIC YEAR 1993-94

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JANUARY 1995

This thesis is submitted in partial submission for the degree of Master of Science

Abstract

Evidence from aircraft accidents indicates that cabin crew can have a positive impact on passengers' ability to effectively evacuate an aircraft. A programme of 24 competitive evacuations were performed in an attempt to determine the effect of cabin crew behaviour upon the rate of egress from a stationary aircraft simulator. Three cabin crew behaviours were assessed; two assertive cabin crew; two non-assertive cabin crew and no cabin crew. The evacuations were conducted on board a Boeing 737 cabin simulator.

A total of 651 volunteers (64.4% male) with a mean age of thirty years participated. All volunteers received a £10 attendance payment. The first 75% off the aircraft received a £5 bonus payment in an attempt to simulate a rush for the exits and to motivate participants to try to egress as quick as possible.

Cabin crew behaviour was found to have a significant effect upon passengers evacuation times. Two Assertive cabin crew produced the fastest mean evacuation times. The results indicated that assertive cabin behaviour is of most importance in the initial stages of an evacuation as it sets the speed for the latter stages. When passengers received no help from cabin crew members their evacuation times were significantly slower than those passengers who had received help from assertive and non-assertive cabin crew.

Passengers evacuated faster when two doors rather than a single exit were available, however in the latter stages of the emergency evacuations individuals' egress time was no longer affected by the number of exits available. At this stage fewer blockages and queues at exits occured, subsequently the number of exits available had no effect on passengers' evacuation times. There was however, no significant difference between the two types of exits utilised in this study.

The number of bonuses a passenger received was found to be significantly affected by gender and age, males received more bonuses as did younger passengers. Passengers questionnaire responses also indicated that they perceived assertive cabin crew members to have greatly aided their escape.

Acknowledgements

I would like to thank the following people for their help with this thesis.

Professor Muir who gave me the opportunity, necessary advice and help to undertake and successfully complete this research.

The Cranfield team for their endless patience and hard work during the late Thursday evenings and wet Saturday mornings.

Ann and Tricia for their invaluable advice.

Kerry, Sarah and Don for all their help.

Finally, John, for his endless support.

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1.0 Introduction

Over the last twenty to thirty years, air transport has become increasingly accessible to the general public. In comparison to other modes of transport, air travel is comparatively safe. Flight safety has improved to the point where a fatal accident will occur on public air transport at a rate of approximately one in every 600,000 flights (Edwards & Edwards, 1990). Although air transport is considered reasonably safe, accidents unfortunately still occur. In 1993, the world-wide fleet of airliners were involved in 127 accidents, in which 1,104 individuals lost their lives (World-wide Accident Summary, 1993).

Whilst the number of air transport accidents are declining, it would seem that should you be involved in an aircraft accident, you are statistically no more likely to survive than you were two decades ago (Taylor, 1989). Whilst primary safety has dramatically improved over the last few decades with measures being taken to prevent major accidents from occurring, the statistics would seem to indicate that secondary measures which are introduced to protect the public in the event of an accident occurring, have not led to a similar reduction in the fatality rate on board the aircraft (Boeing Commercial Airplanes, 1989).

1.1 Accident classification

Accidents may be classified into three categories; 'non survivable', 'survivable', and 'technically survivable'. Accidents are classified as non survivable when crash forces for example are so severe that none of the passengers or crew survive (for example Pan Am 747 in 1988 at Lockerbie). Survivable accidents, are those accidents when all of the passengers and crew survive (for example KAL Airbus A-300, 1994). Technically survivable accidents, include those where some of the passengers or crew survive. This grouping includes accidents such as the British Airtours 737 at Manchester, 1985.

Since 90% of all accidents are either survivable or technically survivable, on many of these occasions an emergency evacuation may be instigated by the cabin crew. The success of such rapid evacuation of those on board is dependent upon a number of extrinsic factors. These include the number and location of exits; any help received from crew and other passengers; whether any of the exits are blocked by fire or impact damage and finally the environment in the cabin and whether there is any fire and/or smoke. Survival may also depend upon intrinsic factors, those attributes which are held by the individual passengers. The physical and mental attributes held by each individual may facilitate an individual's evacuation in the short time available; conversely these may also hinder the individual.

1.2 Factors influencing survival in emergency evacuations

Factors which influence survival in emergency evacuations can be broadly categorised into four groups: Configurational; Procedural; Environmental; and Behavioural (Snow, Carrole & Allgood, 1970). These are shown in Figure 1 with a brief description of each of the factors.

Figure 1. Some Factors Influencing Survival in Emergency Evacuations

(Amended from Snow et al, 1970).

		Examples
Configurational	Standard features of the occupant environment controlling access to exits and evacuation flow rates	Seating density, aisle width, size, number and location of exits, slides, physical exit cues
Procedural	Regulatory and training of crew and other non-passenger rescue personnel which influence evacuation procedures	Experience and training of crew.
Environmental	Features of the occupant space and outside the aircraft which control the evacuation time	Heat and toxic by-products of combustion, secondary explosion, outside light and weather
Behavioural	Psychological, biological and cultural attributes of individual passengers which influence agility and behaviour	Sex, age, knowledge and physical condition of passengers

Research and development of mandatory requirements by the aviation authorities has to date concentrated primarily on the configurational and procedural factors. The aims of which have been to improve and maintain air safety and aid passengers egress during emergency situations. Whilst advances in aircraft design have led to a reduction in the number of accidents, such research and development of mandatory requirements seem to have done little to enhance passenger survivability in aircraft accidents.

With the increasing demand for air transportation and manufacturers designing new airframes which may carry as many as 800 passengers, emphasis is now being placed on finding ways in which passenger safety and survivability can be improved. Recent research has led to changes in seating configuration surrounding Type III exits to be changed, floor proximity lighting and fire hardened cabins to be introduced.

1.3 Behavioural Responses to Emergency Situations

In recent years, attention has turned to how passengers behave during an emergency and how this may have an effect during an ensuing evacuation. Behavioural responses of survivors to aircraft emergencies can be gathered from two sources. Firstly via survivors' accounts and accident reports, and secondly from experimental research. However work in this domain has been somewhat limited. Conducting totally realistic investigations of such areas is impossible due to ethical constraints imposed upon such an area of study and until recently very few survivors' accounts of their behaviour during an emergency have been published.

It has therefore been necessary to supplement the available information from aircraft accidents with information from other emergency situations, such as the Bradford football stadium fire, the Zeebrugge ferry disaster and the Kings Cross fire, allowing a more in depth picture to be constructed relating to the types of behavioural responses adopted by passengers along with the effects of such behaviour, particularly in smoke and fire filled environments. The types of response that have been observed include; flight fight; anxiety; affiliative behaviour; depersonalisation; behavioural inaction and panic.

1.3.1 Motivation to Escape.

Individual motivation to escape may have a great effect on the success of the evacuation process itself. When considering two very similar accidents; one at Manchester in 1985 and one which occurred at Calgary in 1984 which were both caused by an engine fire during take off, the former led to 55 fatalities, whereas in the latter all passengers and crew survived. In some accidents, as in the one at Calgary (1984), it may be noted that everyone filed off in a quick and orderly manner, as was demonstrated in the 90 second aircraft certification (see introduction 1.4). Individuals involved in this emergency evacuation were all frequent flyers and familiar with the aircraft and airline procedures. However, in some situations, as at Manchester (1985), individuals ceased to work in collaboration with each other to get out as quickly as possible and perceived the situation as such a threat to life that their behaviour became directed towards their individual survival. Consequently, this lead to disorganised evacuations, where aisles and exits become blocked and passengers compete to get through exits.

1.3.2 Flight-Fight Response

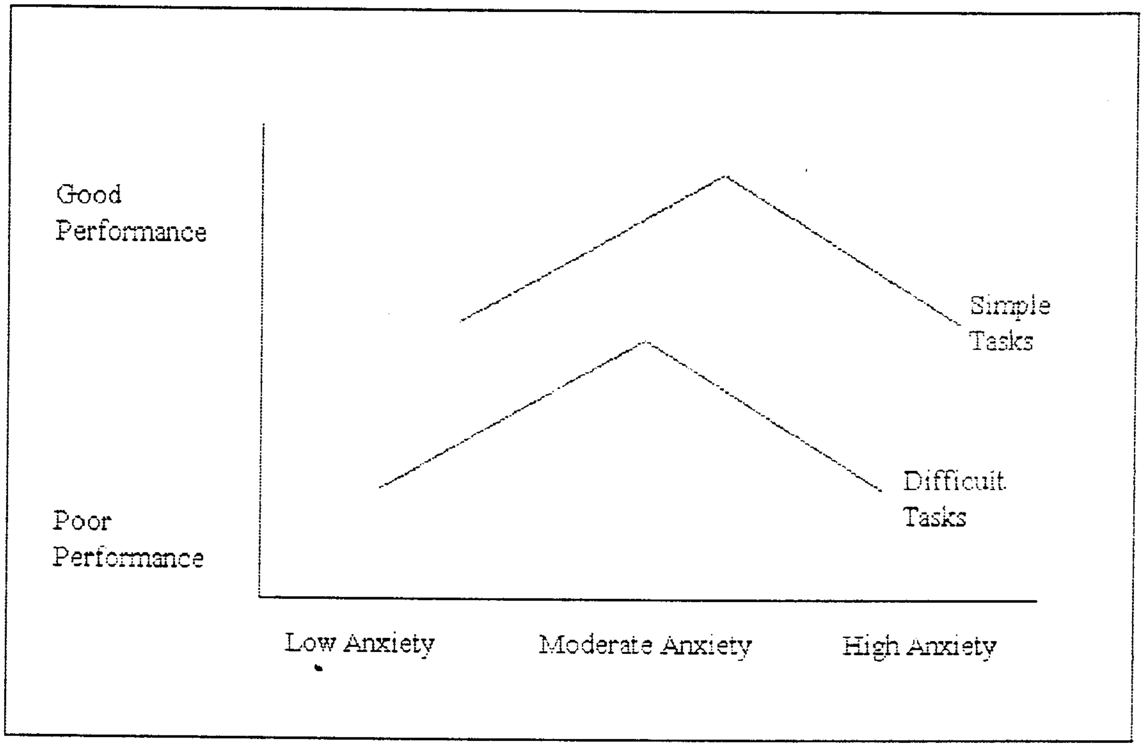
Fear, is the dominant emotion when survival is threatened and underlies all the behavioural responses to an aircraft emergency. Early psychological investigations of fear identified three responses: 'do nothing', 'flight' from the area, in other words escape, and finally 'fight' i.e. attack the agent of harm, perhaps a cabin fire in this instance. The latter is most unlikely as cabin crew are responsible for fire fighting equipment.

Flight may in the case of a small fire involve evacuating a specific part of the cabin; however, should the perceived threat be greater, this may lead to individuals even trying to evacuate before the aircraft has come to a stand still and against the advice of cabin crew.

1.3.3 Anxiety

In an emergency situation which is potentially life threatening and anxiety provoking, passengers are expected to make a series of novel and difficult responses. In view of the relationship now known to exist between individual's ability to perform and their level of anxiety, it is no wonder that egress rate does not reach its optimum level (see Figure 2).

Figure 2. The relationship between levels of anxiety and performance for both simple and difficult tasks (Yerkes-Dobson Law, 1906)



As Figure 2 demonstrates, during levels of high stress ones ability to perform even the most simple tasks can be reduced. An individual in an emergency situation has to quickly respond to the cues he receives. This response will also be affected by how familiar the behavioural response is to that particular situation (Becker, 1973). It has been shown that the performance of even a simple task such as oxygen mask operation (Johnson, 1984) and seat belt operation may be detrimentally effected. The difficulty may be due to individuals reverting to a more familiar mode of behaviour (Spence, 1960). Therefore, an individual is more likely to perform a more familiar response in a highly stressful situation; for example, many passengers, revert to operating the aircraft lap belts as one would an ordinary car seat belt.

1.3.4 Affiliative behaviour

Research by Sime (1985, a) has suggested that behaviour of people trying to escape building fires is characterised by movement towards the familiar. In other words, that the direction of movement will be related to not only the location of the threat but, also the location and degree of familiarity of the individual with attachment objects (i.e. person and place affiliation).

An investigation of a fatal fire at the Summerland holiday complex in August 1973 (Sime, 1985, b), found that choice escape route was influenced by a combination of the persons role; if they were a patron or employee; how familiar they were with the escape route proximity to exits and affiliative ties to individuals in the building

The results found that employees utilised the emergency exits more than patrons who favoured the use of the door of entry (72%). Individuals who were in groups were also shown to delay their escape until all members were present.

Evidence from aircraft accidents does seem to suggest that such behaviour is present. Individuals seem attracted towards the door of embarkation and will go to great lengths to guarantee the safety of those to whom they are emotionally attached.

1.3.5 Depersonalisation

Individuals involved in life threatening events often recount feelings of time slowing whilst mental activity increases. Individuals become 'observers' of the situation, detaching themselves from reality. By doing this it seems to allow them to be able to think and respond more effectively.

Robson (1973), studied passenger behaviour during a period prior to three premeditated emergency evacuations. Cabin crew classified 35% of passengers as calm, 47% as mildly agitated, 2% as very agitated with less than 1% exhibiting signs of uncontrolled panic. Such behaviour can perhaps be accounted for by individuals depersonalising themselves from the situation.

1.3.6 Panic

McDougall (1920), believed that panic was a phenomenon that rarely occurred in a single individual but was present in a group of people when in a dangerous situation. It has been hypothesised that one's expectancy of such behaviour in an emergency situation, can in fact be a major contributor to panic itself (McDougall, 1920; Quarantelli, 1954)

Panic may be defined as uncontrollable and irrational behaviour. The behaviour is characterised by self-preservation at all costs and irrational animalistic behaviour, involving the breakdown of group ties (i.e. 'non-social' behaviour: ignoring of group members; or 'asocial' behaviour: kicking, trampling) (Sime, 1985).

Trimble (1986), concluded from statements from survivors of the 1985 Manchester disaster that,

> "passengers faced with sudden and severe breathing problems will 'panic' and try to extricate themselves from the affected area by whatever means available, including clambering over other collapsing passengers in the aisles or going over the seats." (Trimble, 1986, P.3)

Evidence from such reports does not provide conclusive evidence of whether such behaviour does or does not occur in aircraft emergencies. It is necessary to evaluate studies which have investigated such behaviour in other situations.

Cantril (1958), believed that panic would arise when something which is highly valued is threatened and when there is no obvious relenting by the threat. Pepitone *et al* (1955), studied reactions of people to hypothetical disasters and concluded that such maladaptive behaviour would be more readily exhibited in a situation when great threat to a highly valued object, such as loss of life was perceived. Furthermore, if an individual perceives the threat to be immediate, and the possibility of entrapment dependent on a rapid escape panic will occur (Quarantelli, 1954; Fritz and Marks, 1954).

La Pierre (1938), believed that a group without a clear leader would exhibit panic in reaction to a crisis. Therefore, should cabin crew be incapacitated or unable to provide the leadership necessary to control passengers, panic would be an expected outcome of an aircraft accident.

Mintz (1951), suggested that in an emergency situation that individuals must co-operate as a group. If individuals do co-operate and work towards a common goal, panic will not occur; this has been evident in accidents, for example in Calgary 1984. However, if an individual acts upon his own selfish impulses a conflict will arise between the individual's needs and those of the groups, subsequently leading to panic. This view of panic with individuals competing and behaving in an uncontrolled manner are in fact extremely rare (Quarantelli, 1954; Marrison and Muir, 1989; Fennell, 1992) as Robson (1973) showed in his study (described earlier) approximately 1% of individuals demonstrated panic behaviour.

Whether such behaviour is in fact 'panic', is arguable. Such 'flight' behaviour is characterised by trying to escape a dangerous environment quickly, and by whatever means are available. This may in fact be seen as rational behaviour rather than irrational. Breaux, Canter and Sime (1976), suggest that the intentions and resultant behaviour of individuals are in fact well thought out.

Sime (1993), highlights how 'panic' can be seen as a description of behaviour, that occurs in disasters, created and used by the media to add 'spice' to disaster reports. The two examples below show how the same crowd behaviour may be interpreted very differently.

> "Panic in an assembly audience results in a crowed jamming the exits and causing injuries quite apart from injury by fire. In the type of building now being considered, individuals as well as groups may become panic-stricken. Lives may be lost, for example through fear of using staircases in which there is some smoke but which would actually give safe passage out of a building" (The Ministry of Works, 1952 cited in Sime, 1993).

The same pattern of behaviour is interpreted somewhat differently below.

> "When people, attempting to escape from a burning building pile up at a single exit, their behaviour appears highly irrational to someone who learns after the panic that other exits were available. To the actor in the situation who does not recognise the existence of these alternatives, attempting to fight his way to the only exit available may seem a very logical choice as opposed to burning to death". (Turner and Killan, 1957 cited in Sime, 1993.)

The second quote suggests that behaviour which may been seen as 'irrational' in respect to others, is in fact 'rational' from the perspective of those individuals involved in the incident. This creates problems in both interpretation and definition of 'panic' behaviour because an individual's feelings and motives are often not taken into account. During the emergency the behaviour they exhibited may have been the only way to ensure survival. Such behaviour would probably not be considered by the individual as maladaptive, should they survive. It would seem much flight behaviour could be reported by observers to be panic behaviour.

1.3.7 Behavioural Inaction

Behavioural inaction is classified as a stunned and bewildered response to a disaster situation, a pattern of response described by Johnson (1984), as 'negative panic'. Individuals behave as if they are dazed or immobile, behaviour which is totally inappropriate in an aircraft emergency, especially when fire and smoke is present in the cabin and typically individuals have less than two minutes when conditions are survivable in the cabin.

Allerton (1964), in his behavioural analysis of four disasters reported that 10 to 25% of people behaved in a "confused, anxiety-ridden, somewhat immobile manner". Evidence from aircraft accidents suggests that this mode of behaviour is more likely to occur than panic. Fellow passengers onboard the taxiing Boeing at Tenerife in 1977, claimed to have witnessed others doing little to escape from the burning aircraft. Other survivors of this incident also stated that they had experienced this phenomenon but overcame it, by commanding themselves or being ordered by others to escape. Equally, two fatalities of the DC-9 at Cincinnati (1983), were found sitting with their seat belts fastened, although both were sitting at a considerable distance from the source of the smoke and toxic fumes. Such individuals must have remained inactive until the fire and smoke overcame them.

1.4 Aircraft certification process

In 1967 the FAA introduced a requirement into the federal Aviation Act of 1958 that required aircraft manufacturers to conduct an emergency evacuation demonstration. It stated that a full compliment of passengers should be able to evacuate from half of the aircraft exits in 90 seconds or less. The CAA has the same mandatory requirements.

In several accidents, evacuations have taken longer than 90 seconds to execute. Analysis of information gathered from an accident at Manchester in 1985, in which fifty-five individuals died, showed that it had taken over two minutes for those individuals who survived to egress, during which time half the exits were operational.

The National Transportation Safety Board (1974) has shown that typically, there is 120 seconds available for an emergency evacuation from a burning aircraft. The 90 seconds available during the certification process therefore seems to be a reasonable time for an evacuation of a fully complemented aircraft to be completed in. However, the question can be raised whether such criterion could be met during a real evacuation when heat, smoke and toxic fumes are present.

Further concern over the 90 second test has been raised by Conyers (1992), writing for the committee on Government Operations. The committee raised concern that the exits used during the evacuation trials carried out for certification, were chosen by the manufacturers who were then free to choose those exits which would give the fastest evacuation times. A further limitation raised by the committee was that the 'passengers' used during the certification process are all reasonably fit, and relatively young in comparison to passengers on a 'real flight'. Further more, many of the participants are often employees of the manufacturer who are highly motivated to reach a favourable outcome of the test.

Other limitations of the certification test suggested by the committee are: the use of half the amount of hand luggage on an expected real flight, which is then placed around the cabin and used as obstacles, the aircraft is level and undamaged and finally on board are a full compliment of well rehearsed and highly motivated cabin crew.

Stewart (1986), directed attention to the fact that the certification process is only a means of making comparisons between different aircraft types. He argues that there is no evidence that in a cabin which is full of smoke, fumes and fire that such an evacuation time limit will ensure the survival of all passengers. The 90 second test has been further criticised by the FAA Task Force (1986) who queried the test's ability to show realism as participants all egress in a co-operative and calm manner as no threat to life exists.

Such information raises the question of whether in a 'real' aircraft emergency the 90 second criterion would be achieved.

1.5 Previous research into emergency evacuations.

Early research conducted by Rasmussen and Chittum (1984), investigated configurational changes adjacent to emergency exits. They found that by increasing the seat pitch, or removing the outboard seat adjacent to an overwing exit, the rate of egress could be significantly increased. This research however, was conducted in conditions similar to those in the airworthiness certification tests, and therefore it could be argued lacked realism.

1.5.1 Research into competitive emergency evacuations.

In an attempt to create a more realistic simulation of an emergency evacuation a research programme was developed at Cranfield University using an innovative research methodology; the introduction of a monetary incentive (Marrison and Muir, 1990). Offering a monetary incentive to the first 50% of people to evacuate was found to introduce a competitive element. Using this research methodology, it was found that by altering the width of the bulkhead, time taken to egress via a Type I exit was faster. The optimal distance at the bulkhead was found to be 30″. Seat pitches were varied around the overwing Type III exit. The optimum seat pitch was found to be between 13″ and 25″.

1.5.2 Research into emergency evacuations in smoke

Muir *et al* (1989), considered the rate of egress from a smoke filled cabin. In this study passengers were not offered monetary incentives. The effect of smoke on the rate of egress under different configurations of the bulkhead and seat pitch was the objective of the study. It was found in a non-competitive environment where smoke was present, the optimum bulkhead width was also 30″ and the optimum seat pitch adjacent to the overwing exit was 25″.

1.5.3 Research into competitive emergency evacuations in smoke

The previous research was followed by Muir *et al* (1992), who introduced the element of competition into a smoke filled cabin, using the research pioneered by Marrison and Muir in 1990. Again the effect of smoke and competitive evacuation on rate of egress under different configuration changes was the objective of the study. Findings from the research found faster egress times with a bulkhead width of 72″ (port galley unit removed, through Type I exit). Seat projections of 13″ were optimal for improving evacuation times out of the Type III exit.

1.6 Rationale for this study

In the overview presented above the work which has investigated changes to cabin configuration in both clean air and smoke has been discussed. The use of monetary incentives has allowed a more realistic simulation of emergency evacuations. However, having studied the available literature and accident reports from aircraft accidents and other disasters, it is apparent that a necessity to investigate other factors, such as procedural factors exists.

It was determined that a study to investigate whether cabin crew behaviour during an emergency evacuation can have an effect on the speed of egress was required. It can be argued that their 'leadership style' in such a situation, is of utmost importance. Whilst most leadership theories favour leaders who are relationship oriented leaders, it has been argued by some theorists for example, Hersey Blanchard (1974, 1982), that specific leadership style is directly related to the maturity of the followers of any group. In this context, maturity may be defined as individual competency and confidence to take immediate responsibility for the direction of their own behaviour. During an emergency evacuation, a passenger is in a highly novel situation and probably does not possess the competency and subsequent confidence, to take responsibility for the direction of their behaviour. In this situation, the model suggests that the leader should engage in directive behaviour and tell his/her followers what and how to accomplish the set task. Cabin crew it would seem have the relevant power base to legitimate their position in directing such a task.

Support for such a theory comes from various accident reports. The loss of a DC-10 at JFK International Airport, 12 November 1975 due to a massive bird indigestion, which resulted in an explosion and immediate engine fire, resulted in an emergency evacuation from which all 128 passengers and 11 crew escaped. The success of the evacuation was attributed to the training and background of the passengers, all of whom were airline employees. All passengers had sufficient information and the competency to determine the most effective escape route and the most appropriate action to take.

A TWA Lockheed L-1011 which aborted takeoff from JFK International airport, New York, 1992, indicated the importance of the role of cabin crew members. The aeroplane came to rest, upright and on fire. There were no fatalities among the 280 passengers on board the aeroplane. The nine flight attendants on board (three more than the FAA minimum) were assisted by five off-duty flight attendants and two off-duty captains. The five off duty flight attendants remained at their positions and assisted the evacuation by yelling the commands to passengers to move forward. They also assisted the other flight attendants at their exits. The extra flight attendants directed passengers to other available exits to relieve congestion; they also assisted in keeping passengers moving to and through available exits. The accident report concluded that the:

> "emergency evacuation of the aeroplane was accomplished in an exemplary manner.....despite the rapidly spreading fire that quickly destroyed the aeroplane. ......the performance of the flight attendants and pilots in leading the emergency evacuation prevented significant loss of life." (NTSB accident report, 1992, p64).

In a more recent accident at Cheju, involving a KAL Airbus A-300 (1994), which careered off the runway on landing, all crew and passengers survived. Passengers praised crew members who quelled panic and pushed passengers one by one from the burning aeroplane, just seconds before the fuselage exploded. The cabin crew marshalled all the passengers and chanted in unison "Keep order! One by one!" as they pushed them down the escape slides.

Furthermore in a study by Baumeister *et al* (1988), in which subjects were exposed to a simulated emergency which occurred in the course of a structured group interaction, subjects who were not designated as a group leader, were very unlikely to intervene in the emergency. The group leaders were expected to take control of the situation and when they did not, subordinate group members generally failed to come to the aid of the victim of the emergency. This may in fact have implications during an emergency evacuation in that should the cabin crew fail or be unable to take their leadership role, such diffusion of responsibility may leave passengers unwilling to take control of the situation, expecting the cabin crew to give them the necessary help to aid their escape.

On June 2, 1983, following an inflight rear lavatory fire a McDonnell Douglas DC-9 was forced to land at Cincinnati airport. In the ensuing emergency evacuation 80% of those passengers who had received specific instructions from the cabin crew prior to landing survived in comparison 43% of the passengers as a whole (Barthelmess, 1984). Those individuals who did survive but had not been given specific instructions from the crew escaped with those who did and had pre-planned their escape. Interviews with survivors did suggest that the evacuation could have been helped with enhanced guidance from the crew (Pane *et al*, 1985).

1.7 Objectives

The main objectives of this study are detailed below.

1.7.1 Cabin crew behaviour

The primary objective was to determine the influence of cabin crew behaviour on the exit rate of volunteer members of the public during simulated competitive evacuations. The following types and numbers of cabin crew were explored:

(i) Two assertive cabin crew members

(ii) Two non-assertive cabin crew members

(iii) No cabin crew members

1.7.2 Exit number and type

The intention was to look at the effect of the number of exits in use and the type of exit on egress time. The following configurations were used:

(i) Two doors - both at the front of the cabin; port side exit which is a Type I exit and starboard exit which is a service door.

(ii) One door - port side exit at the front of the cabin, Type I in configuration.

2.0 Methodology

2.1 Experimental Design

The programme of testing involved the evaluation of three different types of cabin crew behaviour. Each of these was tested on four separate trial dates (sessions). It has been shown in previous research that four evacuations was the maximum that passengers and evacuation personnel could carry out safely in one day, before fatigue lead to a drop in safety standards (Marrison and Muir 1990).

On each day, passengers would evacuate the aircraft four times, twice through two doors and twice through a single door. The design of this study therefore involved 12 sessions of four evacuations. Order effects were eliminated by each of the four patterns being run in each of the behaviour types. Experimental sessions followed one of four patterns:

Fig 3: Ordering of evacuation sessions

	Evacuation			
	1	2	3	4
Pattern 1	1 Door	2 Doors	1 Door	2 Doors
Pattern 2	1 Door	2 Doors	2 Doors	1 Door
Pattern 3	2 Doors	1 Door	2 Doors	1 Door
Pattern 4	2 Doors	1 Door	1 Door	2 Doors

This thesis was part of a larger piece of research which involved two different evacuation protocols, which are described in section 2.3.3. However, under the constraints of this contract the two evacuation protocols always followed the same order. Passengers always participated in the two competitive trials first, followed by the two co-operative trials. For the porpose of this thesis, only the competitive evacuation times were analysed as the effect of cabin crew during these evacuations were the interest of this thesis. Any comparison between the two protocols would have been difficult to make due to the consistent ordering of the two protocols.

2.2 Methodological Considerations

In order to remove any factors which may have had an effect upon the time of the evacuations, passengers were not asked to operate any of the exits. If passengers had been required to open the exits, there would have been varying time differences. Cabin crew members were positioned forward of the bulkhead and operated both the Type I exit and the service door. The cabin crew members had all undergone training in the operation of the exits, therefore allowing a constant time of operation of the exits. Included in Appendix A is a layout of the aircraft showing where the cabin crew were positioned.

2.3 Research Design

A Boeing 737, narrow bodied aircraft simulator situated in the College of Aeronautics was utilised for the trials. It was felt necessary that the design and configuration of the aircraft simulator accurately represented those of the front portion of a Boeing 737 in order to increase the realism of the study.

2.3.1 Cabin Crew Behaviour

As the behaviour of the cabin crew on the first evacuation was likely to determine the behaviour of passengers on any subsequent evacuations on a single day, passengers would only see cabin crew members behaving in one of the behaviour types. If for example they had had an assertive cabin crew member during the first evacuation this may well have effected how they behaved in subsequent evacuations with a non assertive cabin crew.

The cabin crew were seated and belted in the jump seat at the front of the cabin. The cabin doors were operated by the cabin crew for both safety reasons and to eliminate any difference in the ability of passengers to operate them.

During the evacuations when two doors were operational, cabin crew members would call passengers to their respective doors, moving towards the bulkhead when necessary. When only the port door was operational, the cabin crew member operating this door would assist passengers on to the slide, while the other crew member advised passengers of the blocked exit and controlled the flow at the bulkhead. How active the cabin crew were during the evacuation depended on the type of behaviour being elicited, as detailed below.

2.3.1.1 Assertive Behaviour

Assertive cabin crew behaviour involved shouting and calling passengers to the exits; the use of hand gestures; physically pulling passengers through the bulkhead when blockages occurred; ordering passengers to calm down; to wait and to stop pushing and pushing them on to the evacuation slides thus avoiding any hesitation.

2.3.1.2. Non Assertive Behaviour

Non assertive behaviour did not involve any physical contact or hand gestures and passengers were asked politely to move forward to the exits. When blockages occurred at the bulkhead, cabin crew members did not physically help passengers and asked rather than told others to calm down.

2.3.1.3 No Cabin Crew.

In no cabin crew conditions, the cabin crew members opened the doors and then exited by the evacuation slides.

2.3.2 Exit Type and Number

The exits in use were both at the front of the cabin. One condition involved both doors being operational, whilst in the other, only one door was in use. The doors varied, the port door was a typical type 1 exit whilst the starboard door was a service door. Differences in egress times of these doors were also investigated.

2.3.3 The Incentive Scheme: a need for realism.

Reports following aircraft accidents have shown that passengers actively compete to survive, especially in an unfamiliar environment, or when not all of the exits are operational (Kelly et al, 1965). Therefore, in order to make the experiment as realistic as possible, it was necessary to introduce some form of competitiveness and motivation for the passengers to exit the aircraft simulator as quick as possible.

Ethical and practical reasons led to the utilisation of the monetary bonus system used in previous series of work in the Department of Applied Psychology (Marrison & Muir 1990, Muir, Bottomley & Hall 1992).

Volunteers all received £10 for participating in the evacuation trials. An additional £5 was awarded to those individuals who were within the first 75% of the passengers out of the aircraft. This protocol was used in half the evacuations in order to try and motivate them to get out as fast as possible (this type of evacuation was investigated for this thesis). The 75% threshold was decided upon as acceptable. Providing fewer bonuses may have led to intense competition with the possibility of injuries, and more may have had a demotivating effect, therefore a compromise had to be made.

The other two evacuations during the trial used a different bonus system whereby passengers would receive a further £5 if during these evacuations they all co-operated with each other and managed to exit the aircraft within 90 seconds. Each volunteer could therefore earn £25 during one day's evacuations.

The seating was arranged so that each passenger had an equal chance of obtaining the monetary bonuses. The seats were rated into two zones, according to their proximity to the operational doors (seat ratings and seat layout may be observed in Appendix A). Two seating zones were used instead of four as in Muir, Bottomley & Hall 1992 because of the two different types of protocols which were used. This meant that during the two competitive trials individuals had an equal chance of receiving a bonus. If the previous system of four zones had been used this would have led to some passengers being seated in zones three and four for the competitive evacuations whilst others may have been in zones one and two giving them an unfair advantage. Passengers therefore sat twice in zone one and twice in zone two, one of each in the competitve evacuations and one of each in the non competitive evacuations. The predetermined plans meant that each passenger would be seated at differing distances from the exits during each evacuation (see Appendix A).

The seating was also arranged so that passengers did not sit next to each other more than once. This prevented passengers from forming groups which may have acted in a detrimental way to others. Passengers were also asked during the briefing prior to the first evacuation, if they were part of a group and to work as individuals and not to aid each other.

2.3.4 Safety Measures

During the series of evacuation trials, safety was of the utmost importance. The very nature of the evacuation trials and the use of evacuation slides for the first time at Cranfield meant a number of precautionary steps were taken to protect the participants.

Passengers both in real accidents and during similar evacuation trials in America have been seriously injured. For these reasons before individuals were allowed to participate in the trials there were sent information explaining more clearly the nature of the study. Volunteers were required to be aged between 20 and 50 and they were asked not to volunteer if they suffered from any of the medical complaints listed on the information sheets, or if they weighed more than 15 stone for men or 12 stone for women. Passengers were all required to sign a medical form stating that they understood the information and the insurance cover associated with the trials. A copy of the information given prior to volunteering can be seen in Appendix B, the insurance and medical forms used during a session are in Appendix C.

Volunteers also received information about the various safety precautions which were taken on the day to reduce the likelihood of injury:

i) Padding and rounded corners in the cabin meant the potential for injury in the cabin was reduced.

ii) Present during each day was a doctor who was available to give medical advice and assistance. The GP was positioned at the bottom of the slide allowing access to the passengers quickly as they moved away.

iii) The evacuation slides which were typical of those on a real aircraft had been specially fitted with a speed resistant surface at the bottom to slow passengers down, padded sides, nets on either side of the slide and mats at the bottom to cushion passengers when they reached the bottom

iv) Four firemen were present throughout the evacuations. They were positioned at the bottom of the evacuation slides to help passengers up and away from the slides.

v) All five members of staff on board the aircraft and Cranfield personnel outside the aircraft had personal alarms. In the event of any problems arising or the possibility of anybody being hurt and the evacuation being too dangerous to continue, these alarms were activated. Passengers had been familiarised with the sound and been told what to do if it was activated. They were all aware that if it was sounded, that meant the evacuation had been halted and that no bonus payments would be made regardless of whether they had already exited the aircraft. This acted as a deterrent to those who otherwise might disregard the safety of fellow passengers. All evacuation personnel were made aware of the need to identify any problems or incidents occurring during the evacuation and the need to react quickly to these.

It was anticipated that these measures would reduce the risk of any serious injury to an acceptable level.

2.4 Materials

2.4.1 Aircraft Simulator Preparation

The aircraft simulator was the main piece of equipment, it was the front half of a 737 and was configured to represent a typical aircraft of this type. The seats were positioned so that they all had a seat pitch of 29 inches.

The aircraft contained 10 rows of seats, 3 either side of aisles. The two cabin crew were seated at the front of the cabin in the jump seats which allowed 60 passengers to be seated in the cabin giving the desired feeling of crowding within the aircraft (a plan of the aircraft can be seen in appendix A).

The bulkhead and galley unit at the front of the cabin were reconstructed to represent a typical 737. The bulkhead was designed to be able to move to various widths, 24 inches being used in this case; above the minimum 20inches stipulated in JAR 25.815.

The two overwing exits were removed for this set of trials and a Type I and a service door operated at the front of the cabin and two emergency evacuation slides which were permanently inflated were used

Floor proximity lighting and emergency exit signs were fitted, the floor lighting ran the length of the aircraft on the starboard side and was operated on the call to evacuate. These were operated from a computer terminal at the rear of the aircraft by one of the evacuation personnel. Cabin lighting and door locking mechanisms could also be controlled from here.

A platform was erected outside what would have been the cockpit to allow a camera to be placed there and an exit from the front of the aircraft via steps. All of these alterations were designed to be as unobtrusive as possible.

2.4.2 Cabin Crew Training

The cabin crew underwent training from the CAA Cabin Safety Officer. This included training the crew to give a correct pre-flight briefing and the type of behaviour they would demonstrate in each of the cabin crew conditions. They were also shown how to operate the cabin doors correctly and how to perform a cabin secure check after each of the evacuation trials; replacing the seats and seat belts to their correct position.

2.4.3 Additional equipment

i) Safety Briefing

Briefing cards were designed following the requirements specified in the Air Operators Certificate CAP 360. They were designed to be consistent with the passenger briefing. Clear, precise illustrations of evacuation slides use were thought to be of great importance as was the update of the brace position to meet NTAOCH 8/9302. A copy of the briefing card can be seen in Appendix D. The briefing cards were shown to passengers during the pre-flight briefing, along with demonstrations of the correct usage of oxygen masks and seat belt operation.

ii) Audio Equipment

A double cassette player was operated by the evacuation personnel at the rear of the aircraft. This was connected to speakers which were at the rear of the aircraft. This was used to play the pre-flight briefing and the various evacuation scenario's which would eventually end with the pilot's command of "Undo your seat belt and get out!". Transcripts of these can be found in Appendix E.

iii) Video Equipment

The behaviour of flow rates and passengers were recorded by the use of video cameras with internal time bases. Two cameras were inside the cabin and five were outside the aircraft.

The cameras within the cabin were mounted at the rear of the cabin and half way down, protected in an overhead locker. These cameras were to be used to give information about passenger behaviour within the cabin. One camera was mounted at the front of the cabin looking towards the bulkhead and was utilised to give information about any blockages that may have occurred at the bulkhead.

The cameras located outside the aircraft were utilised to determine differing flow rates out of the exits, evacuation times and behaviour on the evacuation slides. One camera was focused on the cabin door and one on the evacuation slide on both port and starboard sides of the aircraft. The location of the cameras can be seen in appendix A.

iv) Identification Bibs

Two sets of identification bibs were made. Passengers wore these over their clothes, securing them at the side with tags. Each displayed passenger's seat number, thus allowing their seat position to be related to the time it took for them to evacuate the aircraft. Two sets were used allowing quick change over of bibs between each evacuation.

v) Personal Alarms

Every member of the research team carried a personal alarm. The purpose of these alarms was to signal that an evacuation was becoming too dangerous or that someone was hurt and therefore the trial should be halted. All passengers had been informed that if an evacuation was stopped, no bonus payments would be made regardless of whether they had exited the aircraft prior to the sounding of the alarm.

vi) Polaroid camera

Pictures were taken of each of the participants. These was taken to help with subsequent analysis of the data. Many of the passengers as they exited the aircraft covered their seat number as they adopted the correct position to use the slides. This made positive identification of where they sat very difficult. The photographs which were marked with their subject number made identification of who they were, and therefore their seat number easier

2.4.4 Questionnaires

Questionnaires were used allowing individual passengers' perceptions and experiences to be recorded. A basic questionnaire was given to passengers after each of the evacuations. The questionnaires were all self completion however, a member of the research team who was familiar with the questionnaires was available to answer any questions. This method of administering the questionnaire optimised the time available and may have discouraged passengers from giving 'socially desirable' answers.

The questionnaires contained questions pertaining to this thesis as well as the larger research contract. The questions which were to be used in this thesis are as follows:

i) Whether the cabin crew had aided their escape, and if yes, how?

ii) Did they think there was anything more the cabin crew could have done to have aided their escape, and if yes, what could they have done?

iii) Why they chose the particular door that they exited from.

Copies of each of the questionnaires can be seen in appendix F. In the no cabin crew condition only question iii will be analysed.

Demographic information was also collected about individuals age, sex, weight, height and occupation.

2.5 Pilot Study

The pilot study, conducted using 20 subjects, did not reveal problems with the questionnaire. It was decided that the pre-flight briefing was too lengthy and that the life jacket demonstration should be removed, this was still within the regulations in CAP 360 which states that a life jacket demonstration is only necessary when an aircraft flight is crossing water.

The pilot study enabled the testing of all the equipment used during the evacuation trials. Camera location and sound levels were tested to check that the information required was being recorded correctly. It also enabled the researchers to assess the safety of the evacuation slides and cabin crew behaviour training effectiveness.

The pilot exercise followed the same pattern as the first day of evacuations and was found to run smoothly without any changes deemed necessary.

2.6 Subjects

The design of the study was such that on each of the 12 experimental days different subjects were needed. The subjects were recruited using a non probability sampling method from various sources using posters and adverts. These were distributed around Cranfield University Campus and to clubs and societies. A large advertising campaign in the local papers was also used. Although this method of recruitment may have led to some problems in self-selection bias, the nature of the research meant only those individuals who volunteered themselves could be used.

All of these methods indicated that volunteers would be required for approximately three hours and would undertake four evacuations. Information was also given about the money incentive and bonus system and the age and weight restrictions which were enforced. A copy of a typical advert may be seen in Appendix G.

On request via either telephone or by the tear off slip on the advert, application forms along with further information were sent to prospective volunteers (see Appendix B). Volunteers were asked to fill in the form indicating the date upon which they would like to participate. Participants were then booked into one of the trials and confirmation of the date along with information about the schedule of the day and safety precautions they could take themselves to prevent injury were sent to them (a copy of this can be seen in Appendix H). As far as possible, individuals were allocated their first choice of date. Large groups of people were not booked in together so as to avoid any possibility of them working as a group.

2.7 The Research Team's Roles

Prior to the evacuation day, personnel were appointed to their varying roles and were made aware of what each position entailed. The research team was divided broadly speaking into four areas: administration, safety, cabin crew and technical equipment. These groups were all responsible to the evacuation leader.

A brief description of the roles of each group are detailed below:

Administration - Four members of the administration team were responsible for booking -in and photographing the subjects, weighing and measuring the subjects, distribution of seating bibs and payment of the subjects.

Safety - The four fire officers were responsible for the safe movement of passengers away from the bottom of the evacuation slide. The doctor was based at the foot of the slides allowing immediate access to any individual who may have hurt themselves whilst exiting the aircraft.

Cabin Crew - The three cabin crew members were responsible for seating the passengers in their correct seat on the aircraft and demonstrating the pre-flight briefing. They had all been trained by the CAA Cabin Safety Officer in the procedures to be adopted in an emergency and reacted accordingly to the particular cabin crew condition being tested. The third member positioned at the rear of the aircraft during the evacuation was in charge monitoring and ensuring safety at the rear of the cabin.

Technical equipment - This group was divided in two, one member who was responsible for the operation of all video and audio equipment which was monitored during the evacuation as an extra safety check, and one member who was responsible for any repairs to the aircraft during a trial day.

Evacuation Leader - All these groups of individuals were co-ordinated by the evacuation leader who undertook the briefing and debriefing of the passengers. They assumed a position during the evacuations at the front of the aircraft in the toilet where through a peep hole they could assess the situation at the bulk head. No evacuation was commenced until all the evacuation groups had indicated to the evacuation leader that they were ready for the evacuation to proceed.

2.8 Procedure

2.8.1 Trial Day Schedule

The organisation of the day, was divided into three parts; Pre-evacuation administration and briefing, the evacuations and post evacuation debriefing.

2.8.1.1 Pre-evacuation administration and briefing

The four evacuations were undertaken over a period of three hours. These sessions were held on either a Saturday morning or a Wednesday or Thursday afternoon. Regardless of the day the schedule remained the same.

Participants had been sent information explaining where and when to arrive. As the participants arrived they were met by two of the research team who gave them their subject number; this dictated the four seats they would be given throughout the trials, ensuring that each individual had an equal chance of getting a bonus. Participants were then sent to have their picture taken by one of the cabin crew. They were given a clipboard with all the relevant information, forms and questionnaires on. They were also given a bib with the seat number on indicating where they would sit for the first trial. The clipboard contained the following documents:

i) Two sheets of information repeating information they had already received detailing health, the procedures that would take place and safety precautions that were taken (see Appendix C).

ii) Insurance cover information (see Appendix C).

iii) A medical questionnaire; this asked for details of their age, sex, weight and height. This document also acted as a consent form with participants signing to acknowledge that they had read and understood all the information supplied to them and that they believed themselves to be fit enough to participate (see Appendix C).

iv) Four questionnaires to be filled in after each evacuation (see Appendix F).

v) A sheet of information asking passengers to contact the Applied Psychology Department if they suffered any problems subsequently after having taken part in the evacuation trials (see Appendix C).

Once passengers had read the information and understood it, they were asked to fill in the medical questionnaire. Following this, participants were called in groups to have their height, weight, shoulder width and occupation taken. They were then briefly examined by the doctor who made sure that they knew what would be expected of them during the trials and that they were fit enough to take part. The criteria used to base any judgement on whether an individual could take part can be seen in Appendix J.

Once all the participants had seen the doctor and been weighed and measured, they all congregated together to be given a briefing by the evacuation leader. This explained the reasons for such research being carried out, why the incentive payments were made and how to use the evacuation slides. They were also warned that if behaviour became unacceptable, the trial would be stopped using, the alarms and that no bonus payments would be made. Passengers were not told what aspect of the cabin or procedure was under investigation. It was made very clear to all participants that it was perfectly all right for anybody to drop out at anytime, and that they would still receive their £10 attendance fee.

After the briefing, individuals were asked to place any jewellery, watches, and glasses into envelopes which were sealed with their name on. These were placed, along with handbags in a locked office, to be returned at the end of the session.. Passengers were then escorted to the cabin simulator and seated in their correct seats on board the aircraft.

2.8.1.2 The Evacuations

While passengers were being seated, an initial address was made to the passengers (this along with a transcript of the briefing can be seen in Appendix E). Once all the passengers had been seated, the evacuation leader took their place at the front of the cabin in the toilet.

Passengers were given a typical pre-flight briefing (see Appendix E), following which the cabin crew checked that all the passenger seat belts were fastened tightly and their seat table, arms and seat back were upright. The cabin crew then assumed their position at the front of the cabin seated and buckled in. A sound of an aircraft engine was then heard, four different scenarios were used to try to stop passengers anticipating the call from the pilot to "Undo your seat belts and get out", these can be seen in appendix E. The appropriate doors where then opened by the cabin crew.

Two of the administration team distributed tickets to individuals as they reached the bottom of the evacuation slides. If one door was used then all the tickets were outside this door, if two doors were used then the tickets were divided equally between the doors. These could then be exchanged immediately for £5.

After depositing the bibs which they had worn at the administration point, the passengers then completed the appropriate questionnaire. They were then given their next bib with the seat number on for the subsequent trial.

2.8.1.3 Post Evacuation Debriefing

After the forth evacuation, subjects returned their bibs to the administration point and filled in the final questionnaire. The evacuation leader then gave them a short debriefing in which they were thanked for attending and reassured once again of the unlikelihood that they would ever be involved in an aircraft accident. They were also told that it was the cabin crew behaviour that was being investigated, however they were asked to disclose as little as possible about what the evacuation trials involved to anybody else that they knew who were taking part, so as to keep the element of surprise necessary if the evacuations were to run properly.

3.0 Results

Participants evacuation times and the information obtained from the questionnaires were analysed using the Statistical Package for Social sciences (SPSS-PC). As this thesis was part of a larger piece of research only those analyses which were relevant to the objectives of this thesis have been reported.

3.1 Sample

3.1.1 <u>Test Programme</u>

At the beginning of the programme it was anticipated that two competitive evacuations would be held on each day, of these, one evacuation would utilise one door whilst the other would use two doors. Furthermore, there would be four testing days of each of the cabin crew type: assertive, non assertive and no cabin crew. However as the table below shows on three occasions during the evacuations passengers were being hurt or in danger of being injured subsequently the trial had to be halted. Thus at the end of the 12 trial days, 21 evacuations had been completed.

Table 1 Breakdown of the number of evacuations undertaken by cabin crew type and door number.

Cabin crew type	Number of evacuations		
	1 Door	2 Door	Total
2 Assertive	4	4	8
2 Non assertive	4	3	7
No cabin crew	3	3	6

3.1.2 <u>Participant characteristics</u>

During the trial series 651 volunteers took part, an average of 54 participants on each trial day. All of these individuals were aged between 20 and 50, and had been passed fit to take part by the doctor present during the trial day (the criteria used by the doctor can be seen in Appendix J). The tables below show the average age and percentage of males and females in each of the cabin crew types.

Table 2 Mean age of participants.

Overall		2 Assertive cabin crew		2 Non assertive cabin crew		No cabin crew	
Mean Age	S.D	Mean Age	S.D	Mean Age	S.D	Mean Age	S.D
30.12	7.98	29.68	7.92	30.70	7.92	30.01	8.27

Table 3 Percentage of males and females.

Overall		2 Assertive cabin crew		2 Non assertive cabin crew		No cabin crew	
Male	Female	Male	Female	Male	Female	Male	Female
64.4%	35.6%	65.22%	34.78%	58.85%	41.15%	68.87%	31.13%

Generally subjects had had no previous experience of such emergency evacuation trials. However, the small number of individuals who had taken part in previous trials run at Cranfield were allowed to participate again as long as there had been at least a six month gap, i.e. those individuals who participated in trials during August 1993 were allowed to volunteer in February 1994.

3.1.3 Medical supervision

The requirement for medical attention following each evacuation was minimal. A few individuals suffered from friction burn whilst using the evacuation slides, this was due to individuals not covering their arms as advised. Several individuals did sustain some bruises through their enthusiasm to egress. There was one serious injury during the trials; a female participant incorrectly jumped on to the slide and caught her ankle, leading to a fractured ankle.

It was made very clear to all those who took part in the trials that it was quite acceptable to drop out at any time during the trial day. Overall, 20 participants decided that they didn't want to take part, an average of 1.7 per trial day. 60% of the dropouts were female aged between 20 and 45 years, whilst 40% were male aged between 24 and 50 years old. One individual boarded the aircraft and found that it was too claustrophobic and was unable to continue, the others decided that the experience was too harrowing for them and that they would rather not continue, these feelings were temporary and none suffered any long term problems.

3.2 Quantitative data

3.2.1 Treatment of the observational data

The video recordings of the participants egressing allowed an analysis to be made of the effects of the different type of cabin crew behaviour. The cameras internal time base and audio recordings provided reliable information on the time taken for each individual to evacuate and the order in which they disembarked.

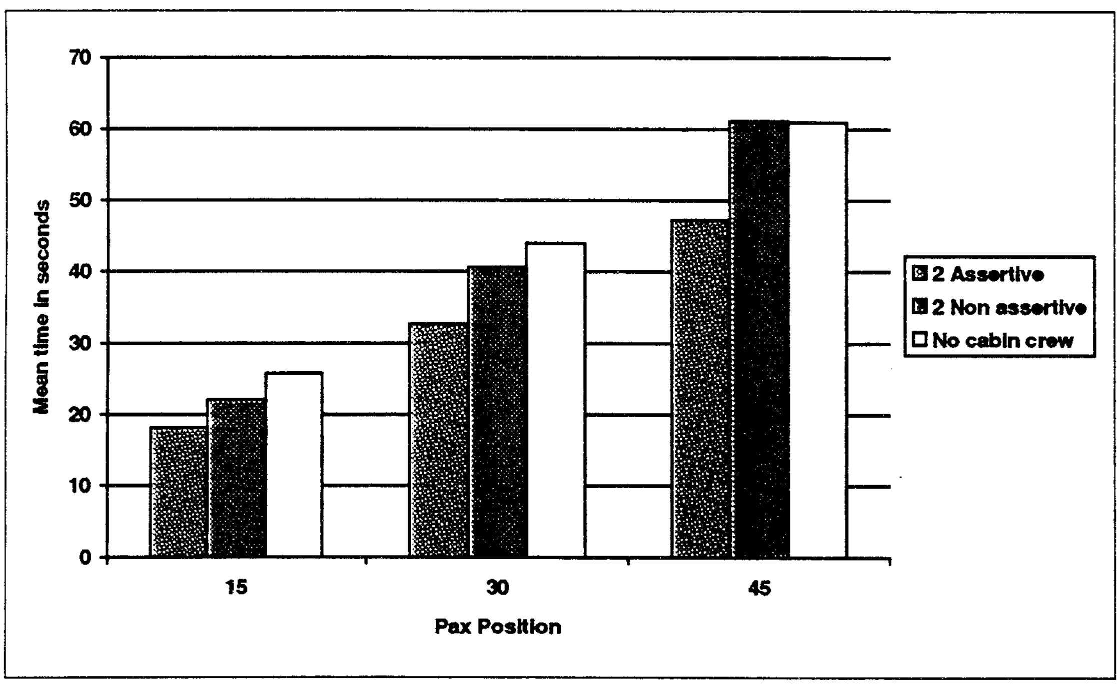
An individuals time to evacuate the aircraft was calculated from when the Captain instructed passengers to "Undo your seat belt, and get out" to when they had reached the bottom of the evacuation slides. Evacuation times were calculated to two decimal places. An independent group design MANOVA was used to analyse the two dependent variables of cabin crew behaviour and door number with the independent variable of time the results of which are detailed below.

3.2.2 Evaluation of cabin crew behaviour

Each of the cabin crew behaviour were tested on four separate trial days; as table 1 above showed some of the evacuations were aborted for safety reasons.

The mean time for the fifteenth, thirtieth and forty-fifth participant (the last participant to receive a bonus, volunteers after this point may not have been competing) was calculated regardless of which door they exited from as it was the effect of the different types of cabin crew behaviour which were being assessed. This enabled a graphical representation to be made of the mean evacuation times of passengers for each of the types of cabin crew. (Re: figure 4).

Figure 4 Mean evacuation times of 15th, 30th, & 45th Passegers by cabin crew type.



A MANOVA was performed on all of the data; the multivariate test of significance for the main effect of crew was highly significant, the Wilks' Lambda was 0.17. The analysis provided two functions by default which are detailed individually in table 4 below. Only the first root which included both functions proved to be significant F=5.68 df 6,24 p= 0.001. The Standardised discriminant function coefficients can be seen in table 5

Table 4 Wilks' Lambda, eigen values and canonical correlations.

Function	eigen Value	Wilks' Lambda	Canonical correlation
1	3.634	0.21	0.886
2	0.264	0.79	0.457

Table 5 Standardised Discriminant Function Coefficients.

Variable	Function 1	Function 2
15th Passengers time	-0.961	1.188
30th Passengers time	0.455	-1.771
45th Passengers time	-0.860	0.610

The univariate F-tests provided a breakdown of how cabin crew behaviour effected the time taken by participants to exit the aircraft. Table 6 clearly indicates that cabin crew behaviour plays a significant part in how quickly passengers can evacuate the aircraft. The cabin crew behaviour had a highly significant effect on the times for the fifteenth, thirtieth and forty-fifth participants. When the same times were entered into a step-down F test, see table 7, which covaried out the effect of the fifteenth participants time out of the time for the thirtieth participants and similarly the fifteenth and thirtieth participants time out of the forty fifth participants time, only the fifteenth participants time remained significant, indicating that how cabin crew behave in the initial stages of an evacuation leads to the success and speed of egress in the latter stages of an evacuation.

Table 6 Univariate F-tests - Effect of crew behaviour on evacuation times.

Time	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
15th	158.57	62.90	79.28	4.49	17.66	0.0001
30th	364.51	157.79	182.25	11.27	16.17	0.0001
45th	704.08	432.68	352.04	30.91	11.39	0.001

Table 7 Step-down F-test - Effect of crew behaviour on evacuation times.

Time	Hypoth. MS	Error MS	Step-down F	Hypoth. DF	Error DF	Sig. of F
15th	79.28	4.49	17.65	2	14	0.0001
30th	21.21	8.07	2.62	2	13	0.110
45th	9.51	8.56	1.11	2	11	0.361

In order to ascertain exactly which type of cabin crew behaviour led to the significant difference in time taken for participants to evacuate the aircraft post hoc tests were used the results of which can be seen below in table 8.

Table 8 Post Hoc T-Tests.

Cabin crew behaviour	t-value	Sig. t
Assertive cabin crew	-5.21	0.0001
Non assertive cabin crew	-0.92	0.374
No cabin crew	4.32	0.0001

Assertive cabin crew behaviour has a highly significant negative t-value, the evacuation times of this group were below the grand mean time. This indicates that participants times were continually quicker than the speed of evacuation in the other cabin crew groups and therefore assertive cabin crew play an important part in the speed of an evacuation. The significant positive t-value of the no cabin crew behaviour indicates that the evacuation times in this group were higher and therefore evacuation time was significantly longer. This suggests that when passengers are left to organise and escape themselves, it can have a detrimental effect to the speed of egress

3.2.3 Evaluation of number of doors available.

The evacuation times dependent on door availability can be seen in table 9. The time taken to evacuate the aircraft, was significantly quicker, $F = 55.80$ d.f 3,12 $p = 0.0001$ when two doors were available in comparison to one, as the mean times in table 9 below show. The multivariate test for significance gave a Wilks' Lambda of 0.07 and an eigen value of 13.95. The canonical correlation was 0.97, the analysis accounting for almost 93% of the variance.

Table 9 Evacuation times and door availability.

	15th Passengers time		30th Passengers time		45th passengers time	
Door number	**Mean**	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**
1	25.64	5.49	48.74	9.41	69.76	12.22
2	17.62	1.98	28.57	2.19	39.22	2.90

Univariate F -test again provided a breakdown of the effect of the number of doors at the fifteenth, thirtieth and forty fifth participants, these are detailed below in tables 10 and 11. Table 12 shows the standardised discriminant function coefficients

Table 10 Univarite F-tests - Effect of number of doors on evacuation times.

Time	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
15th	303.56	62.90	303.56	4.49	67.56	0.0001
30th	1833.61	157.79	1833.61	11.27	162.69	0.0001
45th	4780.26	432.68	4780.26	30.91	154.67	0.001

Table 11 Step-down F-test - Effect of number of doors on evacuation times.

Time	Hypoth. MS	Error MS	Step-down F	Hypoth. DF	Error DF	Sig. of F
15th	303.56	4.49	67.56	1	14	0.0001
30th	123.72	8.07	15.33	1	13	0.002
45th	18.23	8.56	2.13	1	12	0.170

Table 12 Standardised Discriminant Function Coefficients.

Variable	Function 1
15th Passengers time	-0.466
30th Passengers time	0.009
45th Passengers time	-0.825

Table 10 shows a significant F value for all of the evacuation times indicating a clear difference in evacuation time is dependent on the number of doors available. However when a step-down F test was used as table 11 shows, the time for the forty-fifth individual is no longer effected by the number of doors available.

3.2.5 Evaluation of door type.

As the numbers of participants exiting from each door type varied quite dramatically rather than taking a particular passenger position the rate of passengers per minute for each door was calculated. The mean number of passengers per minute can be seen below in table 16. There was no significant difference found when using a related measures t-test between the door types and the number of passengers per minute who exited, $t = -0.48$ d.f 11 $p = 0.642$.

Table 16 Mean number of passengers per minute by door type.

Door type	Mean	S.D
Type I (Port)	35.65	5.99
Service (Starboard)	34.40	5.94

3.3 Biographical correlates

The individual characteristics under review were age and sex and their relation to the number of bonuses an individual received.

3.3.1 The effect of age on the number of bonuses received

The age of the individual was determined to have an effect on the number of bonuses a participant received ($P = 0.0021$). Three groups of participants were compared; those aged between 20 and 30, those aged between 31 and 40 and finally those between 41 and 50. Those participants who were aged between 20 and 30 having greater success and gaining more bonuses than those aged between 41 and 50. (see tables 17 and 18)

Table 17 The effect of age upon bonus number.

Variable	Mean	D.F	F	Probability
Age	20-30 years = 31-40 years = 41-50 years =	2,481	6.25	0.002

Table 18 Post Hoc comparisons at the 0.05 level (Newman-Keuls).

		Age Grouping 1	2	3
AGE	1			
	2			
	3	*		

Note: * denotes pairs of groups which are significantly different at the 0.05 level

Key: 1 = 20 - 30 years 2 = 31 - 40 years 3 = 41 - 50 years

3.3.2 The effect of gender on the number of bonuses received

The gender of a participant was also found to effect the number of bonuses an individual received, Males were more successful than females p = 0.001. The results of the T-test can be seen in table 19 below.

Table 19 The effect of gender on the number of bonus payments.

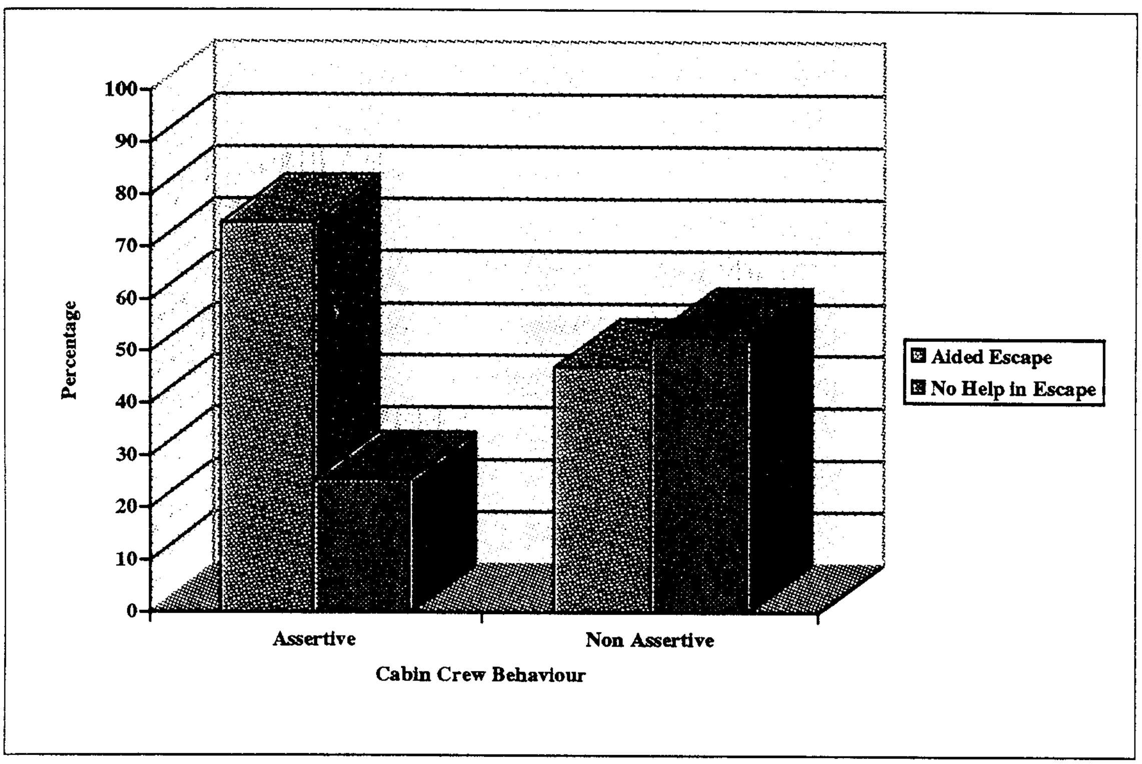
Variable	Mean	S.D	T-value	D.F	Probability
Sex	Male = 1.58 Female = 1.4	0.53 0.59	3.39	335	0.001

3.4 Questionnaire Data

3.4.1 Cabin crew

Passengers were asked whether the cabin crew had aided their escape, figure 5 clearly indicates that passengers felt that assertive cabin crew had been of greater help.

Figure 5 Passengers perception of whether cabin crew aided their escape.



When the passengers were asked how the cabin crew had helped them it is clear that assertive cabin crew were seen to give more help and in a more positive manner (re: table 20).