Office of the
Deputy Prime Minister

Creating sustainable communities

Collection and Analysis of Human Behaviour Data appearing in the mass media relating to the evacuation of The World Trade Centre Towers of 11 September 2001

December 2004

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1. Executive summary

The evacuation of the World Trade Centre (WTC) complex represents the largest full-scale evacuation of people in modern times. The survivors of this disaster hold a tremendous amount of information concerning their experiences of the conditions within the structures and the evolving evacuation scenario. In December 2002, the Building Disaster Assessment Group (BDAG) of the UK Office of the Deputy Prime Minister (ODPM), engaged through the Fire Statistics and Research Division, the Fire Safety Engineering Group (FSEG) of the University of Greenwich to gather, collate, categorise, electronically store and finally analyse data concerning human experiences during the WTC evacuation. Reports were gathered from the literature published in the public domain. Over 250 separate accounts were gathered that described the behaviour of 260 occupants. This report documents these activities and presents the findings of the analysis.

The database contains reference to a total of 3,291 experiences from 260 people derived from a content analysis of the 250 accounts (1869 experiences from WTC1, 1,411 from WTC2 and 11 from unknown locations). Gender information was available for 240 people, 164 of which were male and 76 female. The quality of this data varied enormously. While some accounts were several pages long, others were only a couple of paragraphs in length. The reports mainly came from occupants that begun their evacuation in the upper floors of either tower. Within the database, 73 (61%) and 91 (76%) of the occupants from WTC1 and WTC2 respectively were initially located on or above the 78th sky lobby. In reviewing the findings of this report, it must be remembered that the data on which the analysis is based was not collected in a scientific manner but from accounts in the public domain, primarily press accounts. As such it is difficult to generalise many of the findings. However, as much of the data was reported days after the incident, it provides a unique and insightful glimpse into the human response to such emergencies. The key findings of this research are:

- **OCCUPANT PRE-EVACUATON TIMES:**
  Of the 115 people who provided information on which a pre-evacuation time (also referred to as response time) could be estimated, 60% responded within an estimated 5 minutes of the assault on WTC1 and some 13% took longer than an estimated 17 minutes to respond. Occupants in WTC2 responded quicker to the assault than occupants in WTC1 – the first tower to be attacked. This occurred in WTC2 despite instructions issued over the PA system in WTC2 instructing occupants that there was no need to evacuate WTC2. It is important to note that even under the extreme conditions of the terrorist attack on the WTC, occupant pre-evacuation times can be quite long. A lack of data prohibited a meaningful analysis of pre-evacuation time and proximity to the incident. While it is difficult to generalise due to the lack of data, the rapid response times of occupants in WTC2 relative to WTC1 may have contributed to the smaller death toll experienced in WTC2.

- **OCCUPANT PRE-EVACUATION ACTIONS:**

  (i) State of mind:

  On the whole the description of personal behaviours provided by the evacuees can be categorised as rational. In describing their own actions and behaviours, none of the interviewees reported *Extreme Behaviour* or behaviour that fits the academic view of 'panic'. However, occupants did describe witnessing 5 events that may be interpreted as panic behaviour. This is a surprisingly small number of incidents given the gravity of the event.

  (ii) Nature of pre-evacuation actions:

  On average, occupants reported undertaking 3 distinct actions prior to evacuating. The dominant pre-evacuation action was to seek information. Some 72% of the reported pre-evacuation actions were concerned with communications or with physically attempting to obtain situational information. In attempting to collect information, occupants attempted to make use of television, radio, email and telephones as well as simply moving to widows. Clearly the occupants of both towers were operating in an information deprived state. This is considered significant as the requirement for this action could be removed if occupants could be provided with appropriate information. Reducing the need for gathering information may assist in reducing pre-movement times and overall evacuation times. Improved communication systems and procedures for disseminating information will allow occupants to more rapidly make appropriate evacuation decisions.

  (iii) Knowledge of the event:

  Of the survivors who reported their perception of the event during the pre-evacuation phase, some 41% (20/49) of survivors in WTC1 and some 36% (10/28) of the survivors in WTC2 reported that they thought the incident was the result of an aircraft impact. Thus in both towers, while a large number of people suspected that the incident was aircraft related, the majority of the survivors *did not* believe that the assault was the result of an aircraft impact. This further supports the observation that all survivors did not have accurate information regarding the event.

  (iv) Usage of telephones:

  Of the people who provided information relating to their actions, 20% stated that they made telephone calls. A significant number of these calls (75%) where not to emergency services or colleagues but to family members and the majority of the calls made by survivors were in the *pre-evacuation* phase. Surprisingly, most of these were to assure family members that they were OK – not to secure further information or advice. The propensity of occupants to make telephone calls is considered potentially significant as it is an action that slows occupant evacuation, especially as the majority of calls involved providing rather than receiving information. While it may be considered natural to inform 'loved ones' of ones safety, undertaking this action is ill advised while still exposed to potential danger. It is suggested that as part of regular evacuation training and safety briefings, participants should be advised not to make personal calls until they have safely exited the building as this can prolong evacuation thereby jeopardising their chance of survival.

(v) Collecting Items:
Some 26.5% of the surviving population within the survey (94 people) reported collecting personal items (79% of collected items) or work items prior to evacuating. Most occupants that reported collecting items described collecting items from their desk whilst at their desk or within the immediate local vicinity. However, 6.4% of the surviving population explicitly stated that they had to return to their desk or office from a distant location. Whilst in some instances this action can be accomplished quickly in other instances the action can take considerable time and involve significant additional travel – perhaps in the opposite direction to evacuation. As such the occurrence of this behaviour should be viewed as serious and potentially hazardous. It is suggested that, as part of regular evacuation training and safety briefings, participants should be advised not to attempt to retrieve personal or work items but to evacuate as soon as possible or as soon as instructed.

- **EVACUATION PHASE**

(i) Flow conditions within the towers:
What little data that is available suggests that the stairs were packed and moving slowly below the 44th floor in WTC1 and slow between the 44th and 78th floors. In WTC2 the data suggests that there were lots of people at the sky lobby on the 78th floor. The stairs in WTC2 may have been initially packed and slow moving between the 78th and 44th sky lobbies but later may have become less packed. The stairs below the 44th sky lobby were not densely packed and were fast moving. Most flows were described as orderly even those that were slow and heavily congested. Unfortunately, due to deficiencies in the available data, such as clear indications of time frames, location on stairs and which staircase was used, it is not possible to provide a more detailed analysis.

(ii) Obstructions to flow:
A number of accounts from WTC1 highlight situations in which non-injured occupants progressed down the stairs in single file, allowing injured occupants to be assisted down the unobstructed lane. This altruistic behaviour supports the view that the evacuation was calm and non-competitive in nature. A few accounts also describe the passage of firefighters up the stairs. The accounts that are available suggest that the firefighters may have hindered the passage of some occupants in WTC1, but it is not clear if this had a significant impact on overall evacuation times. The available accounts describe firefighters as constricting the effective width whilst moving up the stairs and while recovering from fatigue. It is suggested that as part of firefighter training, firefighters be instructed that during the ascent of tall buildings, prior to taking a rest period, they should move off the stairs, if considered safe, in order not to obstruct the flow of evacuating occupants. Several accounts describe the flow as coming to a complete halt. All of these reports were taken from floors below the 44th floor. These events may have contributed to the poor flow conditions reported in these areas of WTC1. Water was also reported by occupants below the 44th floor of WTC1. The presence of water would have served to slow occupant evacuation as movement rates would have been severely hindered by the presence of water and several occupants reported slipping in the treacherous conditions. Reports of the injured and firefighters impacting the flow conditions in WTC2 were far fewer.

(iii) Usage of elevators as a means of evacuation in WTC2:
There are 95 occupant accounts reporting evacuation phase experiences in WTC2. Of these, 28.4% (26 accounts) report elevator evacuation usage prior to the attack on WTC2 and represent some 38 elevator embarkations. While this represents a significant usage of elevators, it is not possible to conclude from this information alone that the elevators played a significant positive role in the evacuation success of WTC2. However, it would appear reasonable to assume that the heavy reported usage of elevators in WTC2 prior to the assault on that building could have made two positive contributions to the evacuation. Firstly, heavy usage of elevators would have assisted clearing large numbers of people from the upper floors of WTC2 prior to the assault on that building. Secondly, the usage of elevators by significant numbers of people would have eased the congestion on the stairs in WTC2, making movement on the stairs more efficient. However, a significant number of people also delayed their evacuation – some with fatal consequences – waiting for elevators. Clearly, more research is required in exploring how elevators can be effectively used in large scale building evacuations.

(iv) Group Behaviour:
Of the WTC1 accounts that allowed an assessment of group formation to be made, 90% (62/69) suggested the formation of some type of group during the pre-evacuation phase. In WTC2 a similar trend was noted with 88% (69/78) of the population describing forming groups. Only 10% (WTC1) and 12% (WTC2) of occupants that made an evacuation reported evacuating by themselves. In WTC2, 90% (19/21) of the groups that formed were small (less than 5 people) and very few large groups formed. Indeed, 62% (13/21) of the groups involved only two people. In contrast in WTC1 we find that group sizes tended to be more evenly distributed between small (less than 5), medium (6 to 10) and large (greater than 10).

Of the groups in WTC1 and WTC2, 80% (12/15) and 71% (20/28) respectively, consisted of employees from the same office and 13% (2/15) and 18% (5/28) of groups consisted of a mixture of office and adjacent office employees. This information combined with the group size information may suggest that in WTC2 evacuation decisions were taken on a local/personal basis perhaps involving small localised groups of colleagues. In contrast, in WTC1 larger groups tended to form and this may have been based on collective decisions centralised on an office basis.

Group size was found to be dynamic in nature, expanding and contracting during the evacuation. When groups contracted in size, the predominant reason for this was the deliberate action of a group member, not adverse environmental or situational conditions forcing a group to split. In WTC1 a significant number of the groups that formed split during the (6/10) descent, primarily for deliberate and individual reasons. In WTC2, a smaller proportion of groups split during the descent (8/20). Here again, the predominant reasons for breaking the group were based around deliberate actions by groups members.

The vast majority of groups for which there is sufficient information were led by their line manager during pre-evacuation. Clearly, organisational managers and authority figures are likely to be figures of authority in emergency situations and so they should be well versed in emergency procedures. If possible, line managers should receive fire warden training. However, due to the nature of their organisational roles, line managers and authority figures are likely to spend a considerable amount of their time away from the office. Thus, they should be considered an additional resource rather than the sole fire trained asset.

The observations relating to group behaviour are considered significant. If substantiated by more detailed studies into the WTC disaster, they should have a profound impact on evacuation planning and modelling as groups can exert a significant influence on a range of evacuation parameters such as *Response times, Travel speeds, Way Finding and overall evacuation efficiency and time*. Furthermore, due to its nature, the type of group behaviour noted in this study is unlikely to occur in evacuation drills or exercises. The study of real incidents such as the WTC disaster provides the opportunity to study group behaviour that is extremely difficult, if not impossible to reliably reproduce in 'laboratory' or controlled experiments.

(v) Stair Travel Speeds:
Stair travel speeds for occupants in WTC2 were faster on average than those for WTC1. Mean stair descent rates of between 1.8 floors/min and 2.1 floors/min were estimated for WTC1. In contrast, the data from WTC2 suggests a mean descent rate of between 2.1 floors/min and 3.0 floors/min. Analysis of this data suggests that in WTC1, optimistically, mean movement speeds could have been as low as 0.33 m/s with a spread in travel speeds of 0.25-0.41 m/s. In WTC2, the mean average movement speed using only the reliable data for WTC2 was optimistically estimated as 0.49 m/s with a spread in travel speeds of 0.2-0.7 m/s. These travel speeds are consistent with the implied conclusions that the available data for WTC2 is strongly focused on occupants who commenced their evacuation prior to the assault on WTC2, and hence prior to adverse physical conditions developing. Crowding of people on stairs would also have been reduced by the considerable number of people using elevators.

(vi) Fire Wardens:
Of the official fire wardens 71% (6/7) perished in the disaster while 17% (1/6) of the unofficial fire wardens perished. The unofficial fire wardens mainly assumed responsibility for rounding occupants together and issuing instructions to evacuate their office or office floor. None of the identified official or unofficial fire wardens reported evacuating without having undertaken their assigned (or assumed) responsibilities. There was no indication to suggest that people disobeyed the commands of the wardens.

(vii) Fatigue:
Several accounts of fatigue reported by female occupants were due to the nature of the foot wear worn. Discarded female footwear was also reported on the stairs. These accounts suggest that it would be useful for high rise occupants to be instructed to remove inappropriate footwear in the event of evacuation. It would however be beneficial for occupants not to discard their shoes but to carry them in the event that potentially dangerous debris, such as glass, is present along their route.

This study has provided insight into the response of people subjected to extreme emergency conditions in high rise buildings. The information is useful in its own right in understanding how the evacuation of the World Trade Centre Towers evolved on 11 September 2001. More significantly, the insight gained will be useful in shaping our building codes and devising emergency procedures for evacuation. Furthermore, the information collected will be invaluable in assisting the development of behaviour models that are key components of evacuation models used in performance based building design and in providing data for model scenario specification.

2. Introduction

The evacuation of the World Trade Centre (WTC) complex represents the largest full-scale evacuation of people in modern times. The survivors of this disaster hold a tremendous amount of information concerning their experiences of the conditions within the structures and the evolving evacuation scenario. Only they know what they were doing immediately prior to and during the incident. By tapping into their experiences it is possible to investigate the inter-related processes associated with decision making, action planning and implementation and the information gathering activities which sustains these processes under adverse and rapidly changing conditions.

Ideally, this information should be gathered from face-to-face interviews conducted as part of a scientific study. An alternative and less desirable approach relies on first hand accounts that have appeared in the mass media. These are usually the result of press interviews conducted by journalists or personal accounts produced by survivors on web sites or books. The difficulties with this approach include; an inability to target specific groups, interviewees are self selecting, journalists tend to only report the more sensational parts of peoples stories, inconsistency in questions posed, questions posed by journalists are not necessarily known, inability to ask specific questions. In effect, the accounts that appear in the mass media provide an uncontrolled snap shot view of the incident, and what we don't know from these accounts is as important as what we do know.

Nevertheless, the data contained in such accounts can prove extremely useful in providing insight into behaviour during such incidents. Furthermore, the accounts were recorded very close to the event, some accounts being made a matter of days after the incident. Studies involving live interviews with survivors usually view the incident after the passage of a considerable amount of time, (in the case of the WTC, years) and so may be tainted by information gleaned from other accounts that have appeared in the public domain, memory lapses or selective amnesia. Therefore, the data collected from published accounts while not ideal, potentially contains invaluable information.

In December 2002, the Building Disaster Assessment Group (BDAG) of the UK Office of the Deputy Prime Minister (ODPM), engaged through the Fire Statistics and Research Division, the Fire Safety Engineering Group (FSEG) of the University of Greenwich to gather, collate, categorise, electronically store and finally analyse data concerning human experiences during the WTC evacuation. Reports were gathered from the literature published in the public domain. Over 250 separate accounts were gathered that described the behaviour of 260 occupants. This report documents these activities and presents the findings of the analysis.

3. The Event

While the events of 11 September 2001 are well known, it is worth recounting the main facts. The North Tower (WTC1) was hit by American Airlines Flight 11 at 08:46 a.m. The impact was nearly centred on the north face of the building which was hit between the 94th and 98th floors. The South Tower (WTC2) was hit by United Airlines Flight 175 at 09:03 a.m. The impact was at a skewed angle toward the southeast corner of the south face of the building which was hit between the 78th and 84th floors. WTC2 collapsed at 09:59 am and WTC1 collapsed at 10:28 am. There are various estimates for the number of people in the building and the number of fatalities. Denis Couchon of US newspaper ***USA Today*** estimates that there were between 5,000 and 7,000 people in the buildings at the time of the impact and estimates that 2,784 people perished (including those in the aircraft and emergency services) [1]. He estimates that 1,432 *building occupants* perished in WTC1 and 599 in WTC2 [2].

4. The data

This study focused on publicly available published accounts from WTC occupants. As described previously, this source of data is less than ideal when attempting to analyse human experiences. However, interview data from surviving occupants was not publicly available and financial constraints associated with this study prohibited any attempt at eliciting information via face-to-face interviews. As such this study focused on what was available, namely published accounts from occupants.

Reports were gathered from literature published in the public domain. Material sources ranged from survivor accounts printed in newspapers and newspaper web sites, interviews in the electronic media, survivor web sites and books. Over 250 separate accounts were gathered that described occupant behaviour. Information appearing in print newspapers represents 70% of the accounts while information from websites (news and personal) represents 16% of the accounts. The remainder of the accounts have appeared in books, journals and the electronic media. These accounts provided information concerning 120 people from WTC1 and 119 from WTC2 and 21 of unknown origin.

The quality of the data varied enormously. Some accounts covered several pages of text and contained a great amount of detailed information. Others consisted of several lines and contained little useful information. A 'good' account typically comprised:

- Sufficient detail of each of the occupant experiences,
- Details of locations that events took place,
- A coherent order to events,
- Better still, reference to key markers during the evacuation, such as T1 impact, T2 impact, T1 collapse, T2 collapse,
- Information about others with whom they evacuated.

An example of a 'good' account is shown below:

"I got to work especially early that day. I did the usual routine of buying my coffee, going outside by West Street for my cigarette, and heading upstairs to the 87th floor to my office. It was a Tuesday and I was the first one in. I checked sat at my desk and responded to my e-mails when Christine came in, who was later joined by Fred and Joseph. Christine and I chatted about our plans for the day and I commented on how she was in early. She said that later that day she was going to leave and head over to our other office on John St. to get some work done. At this time, it was about half past 8.

Shortly after that I heard a noise, It sounded like I was on the platform of a subway station and the train was coming full speed ahead. I remember thinking "What the hell is that" It was then that I heard a crash, the ceiling came down, and fire consumed parts of the office and the entire hallway. I was terrified. My boss Christine said "Yvette, get under the desk" to avoid the ceiling coming down on me, so I did.

The fire was unreal and the smoke was getting thick…I could hardly breathe. I crawled over to my boss's cubicle to grab onto her and reached for my cell phone so I could call my sister. Christine grabbed a phone and called 911, she waited on hold then hung up. We could hear the sirens of the fire engine instantly after the crash. I looked out the window and saw streams of what I thought was water coming down, I later found out it was jet fuel. I was scared …I was confused. It felt like a dream, as if I was not even there. The service on my phone was down and Fred was calling out "who is here?" Christine answered for the both of us "Yvette and Christine are here, what do we do?"

Fred came for us, grabbed bottled water out of the fridge, paper towels to cover our faces and led us out the side door to the stairs. We ran around the hallways looking for the stairwell…now sure where it was we followed some other people, some brave enough to stay behind and fight the fire. We made it to the stairs and proceeded down as fast as we could without panicking…after all we still had no clue what was going on. We reached the 78th floor stairwell and it was locked, a man tried to break it down with a fire extinguisher and failed, the door was metal and was impossible to break down, he then tried to bash in the wall next to the door to create a passageway to crawl through…again it wasn't going to happen. People yelled "Open the door" unaware that it was locked.

We then had to be re-routed upstairs a level and find another stairwell. We were finally steadily moving down the stairs, and we were all calm. We joked and laughed, a man from the 88th floor told us that a plane had hit the building…we just assumed it was a small plane and that everything was going to be all right. We eventually got down about 40 flights of stairs and saw firefighters sweating carrying all their equipment and wearing their heavy coats. It was another relief to us. It was still a little smoky but we knew it was smokier upstairs so we gave them our bottled water and wished them well. They were all young, good-looking and so unbelievably brave. They smiled at us and looked so focused. They are my heroes! As they were going up, the last thing on our minds was that they may never come back down, but I don't believe they ever did.

We talked some more on the stairs about the bomb in 1993, and conspiracy theorist on the stairs had there own conclusions about what was happening…but no one took it seriously. As we were approaching the plaza level of One World Trade Center, the firemen said "Just keep walking" and advised us not too look out the windows, and continue down the escalator…but of course we did. It was completely gray, glass was broken and debris was scattered through the plaza, what was usually filled with employee's, vendors, and tourists was completely empty and look like it had been deserted. The firemen insisted that we keep walking and we all cheered as we got to the mall level.

The sprinklers sprayed us from above, "we made it" I remember Christine saying, with tears in her eyes…and we finally met up with Fred again, whom we had lost on the stairs. It was then that I heard that same terrible rumble, what a horrifying. Christine and I ran, the lights went out and you could not see a thing, Fred later said that he thought he had gone blind. We hit the floor. We held on to each other in a fetal position as a tidal wave of concrete dust, debris, and shattered glass, came flying all at once from behind, rolling over our backs for what seem like forever. I screamed "PLEASE GOD…PLEASE GOD" repeatedly.

It was over, my shoes were gone, one of my shoes was blown off and I just sort of ditched the other. You could hear people calling for each other "Is anyone near me? Please reach for me" Christine then answered her "Yes! We're here, we're right next to you." and we reached for her…no one wanted to leave anyone behind…we were a team that had a mission to help and to survive.

Two World Trade Center had collapsed. We grabbed onto each other's ankles and crawled through the darkness, over the glass and debris. We didn't know where to go or what to do. It was impossible to breathe because of the concrete dust and we still could not see. I could hear a man calling out "over here" we crawled over to him toward a faint light that turned out to be the 1/9 subway entrance. We stood up. A few people stood in the doorway looking for help. We heard a fireman call out to us "Is anyone down here?" "Follow the light and I'll lead you out" we saw a faint light but it was difficult to see, it was like putting on your brights on an incredibly foggy day. You couldn't make out faces, you could just see figures and hear voices. I couldn't walk; I had no shoes on. A man, like an angel came over to us and offered to carry me on his back. Without complaint, without hesitation… only he did say "Damn girl, whatcha been eatin'" I responded by hitting him a number of times in the shoulder and laughing…he made me feel better.

We reached the street level, he put me down, Christine, and I gave me a hug and thanked him. Christine returned his laptop, which he dropped while he picked me up and he was grateful. Our faces were gray from the soot and concrete dust, I don't think I could ever recognize him, although I wish I could….etc."

In contrast the absence of most of the above characterised 'bad' accounts. For example:

"Fire engines lay buried in the rubble, Joe Lashendock, a rescue team member, said. "Firefighters came across a lady and a fireman," he said. "The lady was alive. Firefighters went down in the hole. She requested water. They sent in a basket and a neck brace. We all made a chain. She was breathing. Her hand was moving. We said, 'We're going to get you out of here.' She just looked at us. It makes it all worthwhile for the one."

Or

"Louis Lesce was on the 86th floor of the north tower when the jet hit the building. He got down the stairs before it collapsed. "But when we opened the door there was a black wall of smoke. Someone said to me: 'You know, you look kind of tired, buddy. Let me hold your jacket.' And he did. Someone else asked to hold my briefcase. We made it all the way down." Then the building collapsed. With seven others, he managed to work his way out of the rubble."

A narrative analysis was then performed on the accounts. From 'good' accounts (such as the example presented previously) it was sometimes possible to extract information about more than one occupant's human behaviour. Where this was possible they were included in the database and marked as derived accounts. For example, below is the same 'good' extract presented previously with information specific to three different occupants highlighted in colour:

Figure 1: **Example of a 'good' account containing details of more than one occupant**

Yvette Fred Christine

At this time, it was about half past 8. Shortly after I heard a noise. It sounded like I was on the platform of a subway station and the train was coming full speed ahead. I remember thinking "What the hell is that?" It was then that I heard a crash, the ceiling came down, and fire consumed parts of the office and the entire hallway. I was terrified My boss Christine said "Yvette, get under the desk" to avoid the ceiling coming down on me, so I did. The fire was unreal and the smoke was getting thick. I could hardly breathe. I crawled over to my boss's cubicle to grab onto her and reached for my cell phone so I could call my sister. Christine grabbed a phone and called 911, she waited on hold then hung up. We could hear the sirens of the fire engine instantly after the crash. I looked out the window and saw streams of what I thought was water coming down. I later found out it was jet fuel. I was scared. I was confused. It felt like a dream, as if I was not even there. The service on my phone was down and Fred was calling out "who is here?" Christine answered for the both of "Yvette and Christine are here, what do?" Fred came for us, grabbed bottled water out of the fridge, paper towels to cover our faces and led us out the side door to the stairs. We ran around the hallways looking for the stairwell ... not sure where it was we followed some other people, some brave enough to stay behind and fight the fire. We made it to the stairs and proceeded down as fast we

In total over 300 written textual accounts were found. Some of these data sources referred to the same occupants but provided slightly different information. Where possible multiple data sources for the same individual occupant were integrated together within the database.

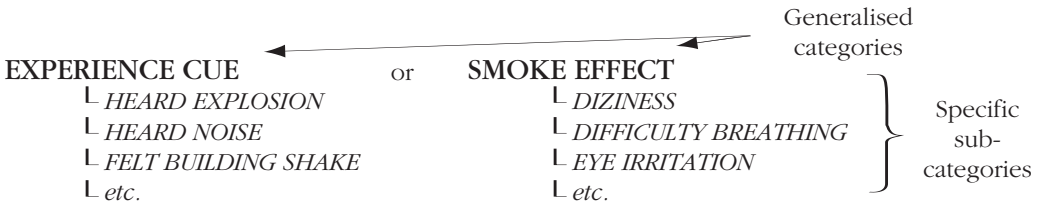
5. The database

The collected accounts were entered into a specially developed database developed using Microsoft Access. The database itself was designed to be a flexible qualitative research tool enabling the categorisation of occupants' experiences during the data input process. As part of the data entry, the entire verbatim data account was stored. In addition, as part of the content analysis, each individual experience described within the account was stored and assigned specific behavioural references. This is similar to traditional qualitative analysis tools that allow users to categorise portions of textual accounts during the input process. A brief description of the database may be found in this section. A fuller description can be found in Annex 1.

5.1 OCCUPANT EXPERIENCES

The categorisation of each experience involved assigning a main behaviour classification to the experience, for example, *'Experienced Cue'* or *'Smoke effect'*. A further refinement to the category was then specified that described the exact nature of the experience, for example the exact nature of the cue or smoke effect (see Figure 2).

Figure 2: **An example of the experience categorisation scheme**



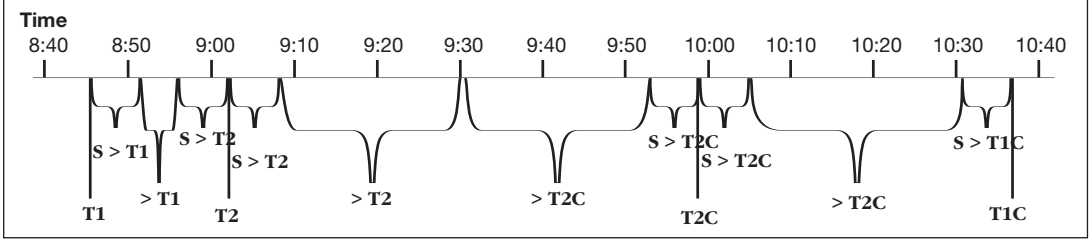
The rationale for the database was that all information was centred on an experience. Each experience was assigned a main category and a sub-category that described the nature of the experience. The experience was also tagged with details of the experience location, time reference, evacuation phase and references to the personal details of the occupant that described the experience. A distinguishing feature of the database is that it is not only able to store experiences but also the location of the experience and a time reference for the experience. The developed database proved well suited for investigating time critical evacuation issues.

The database contains reference to a total of 3,291 experiences from 260 people (1869 accounts from WTC1, 1411 from WTC2 and 11 from unknown locations). Gender information was available for 240 people, 164 of which were male and 76 female. The quality of this data varied enormously. While some accounts were several pages long, others were only a couple of paragraphs in length. Of more importance, some accounts provide important detailed information such as a detailed description of events, locations at which events took place and reference to key time markers. The reports mainly came from occupants that begun their evacuation in the upper floors of either tower. Within the database, 73 (61%) and 91 (7%) of the occupants from WTC1 and WTC2 respectively were initially located on or above the 78th sky lobby. It is likely that this bias originates from the media's natural desire to focus on accounts that described the most extreme conditions during the disaster.

5.2 TIME REFERENCES

Four key event markers were identified; namely the impact into WTC1 at 8:46am, the impact into WTC2 at 9:03am, the collapse of WTC2 at 9:59am and the collapse of WTC1 at 10:37am. Using these time makers in some accounts it was also possible to determine those experiences that occurred shortly before the key event markers, arbitrarily defined as within 5 minutes.

Figure 3: **Time references used within the database**



T1 = WTC 1 impact, T2 = WTC 2 impact, T*n*C = WTC *n* collapse, S = shortly, < = within 5 minutes prior to, > = within 5 minutes post

This yielded an additional 6 markers. The remaining temporal gaps were assigned markers. The large period of time post T2 impact + 5 minutes to T2 collapse – 5 minutes was divided in two (see figure 2. Essentially the analyst entering data had to decide whether an action occurred nearer to T2 (WTC2 Impact) or T2C (WTC2 collapse). Where the researchers could not identify a clear unambiguous time marker due to insufficient information being available, a time reference was not included within the database entry. Each time entry was checked independently by two researchers, differences in interpretation were explained and a final ruling made.

6. Data analysis: Pre-evacuation

6.1 PRE-EVACUATION TIMES (RESPONSE TIMES)

A key part of this study related to the generation of an estimate for occupant pre-evacuation time also referred to as occupant 'response time'. In most evacuation situations the response time or pre-evacuation time is of paramount importance in defining the evolution and ultimate success of the evacuation. It is also a key component for evacuation modelling.

In this study, the pre-evacuation time encompasses all activities undertaken by occupants prior to the flight action i.e. decisive actions directed at exiting the floor and building. For example, pre-evacuation activities included behaviour in which a person begins to attempt to vacate their starting floor but, prior to entering the staircase, decides to return to their office to collect belongings. Likewise an occupant moving to a different room to seek shelter would also be classed as engaging in a pre-evacuation activity. This distinction is subjective but allows for the differentiation

between actions and experiences that occurred during descent (and in some cases ascent) and activities that occurred more locally to occupants' work places. Using this approach a surviving occupant would sequentially progress through the following phases: pre-evacuation, evacuation, post-evacuation.

Using this definition of pre-evacuation, it is possible to examine the amount of time occupants typically spent involved in the pre-evacuation phase i.e. their response time. Recall that each experience within the database was attributed (where possible) with a marker that represented the approximate time period that the experience took place. Using these markers it was possible to generate an estimate of occupants' response times. The point at which each occupant began to evacuate was record in one of the following bins.

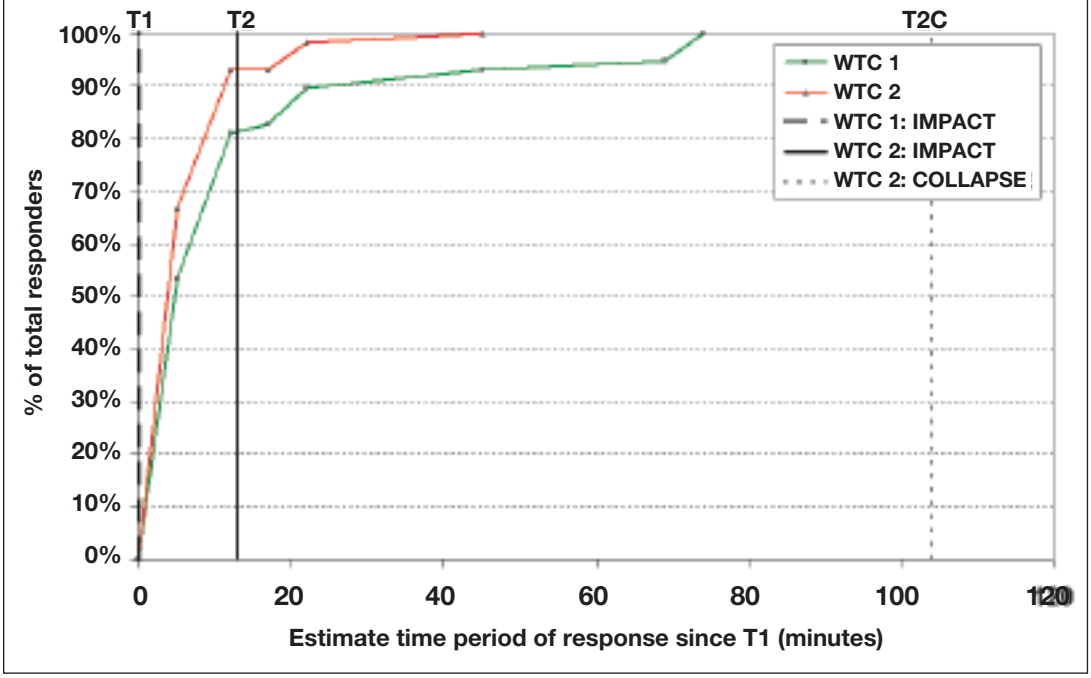
T1 = WTC1 impact (8:46),
T2 = WTC2 impact (9:03),
T2C = WTC2 collapse (9:59),
T1C = WTC1 collapse (10:28),
S > T1 = Shortly after the T1 impact (i.e. between 8:46 and 8:51),
S < T2 = Shortly before the T2 impact (i.e. between 8:58 and 9:03),
S> T2 = Shortly after the T2 impact (i.e. between 9:03 and 9:08),
S < T2C = Shortly before the T2C (i.e. between 9:53 and 9:59),
S > T2C = Shortly after the T2C (i.e. between 9:59 and 10:04),
S < T1C = Shortly before the T1C (i.e. between 10:23 and 10:28),
> T1 = Some time between S>T1 and S<T2 (i.e. 8:51 to 8:58),
> T2 = Some time between S>T2 and <T2C (9:08 to 9:31),
< T2C = Some time between >T2 and S<T2C (9:31 to 10:04),
> T2C = Some time between S>T2C and S<T1C (10:04 to 10:23).

Table 1: **Pre-evacuation data for WTC1 and WTC2**

	Maximum time period since T1 (minutes)	Number of WTC1 accounts	Cumulative total for WTC1	Number of WTC2 accounts	Cumulative total for WTC2
8.46	0	0 [0%]	0	0 [0%]	0
8.46-8.51	5	31 [53%]	31 [53%]	38 [67%]	38 [67%]
8.51-8.58	12	16 [28%]	47 [81%]	15 [26%]	53 [93%]
8.58-9.03	17	1 [2%]	48 [83%]	0	53 [93%]
9.03-9.08	22	4 [7%]	52 [90%]	3 [5%]	56 [98%]
9.08-9.31	45	2 [3%]	54 [93%]	1 [2%]	57 [100%]
9.31-9.54	69	1 [2%]	55 [95%]	0	0
9.59-10.04	74	3 [5%]	58 [100%]	0	0

These response ranges were selected primarily on the basis of the markers contained within the database. The rapid response range encompassed markers T1 and S<T1 (up to 5 minutes i.e. between 8:46 and 8:51), the moderate response range encompassed >T1 and S<T2 (between 5 and 17 minutes i.e. 8:51 to 9:03). All other markers fell into the long response category (i.e. greater than 17 minutes).

Figure 4: **Percentage cumulative frequency distribution of occupant response times**



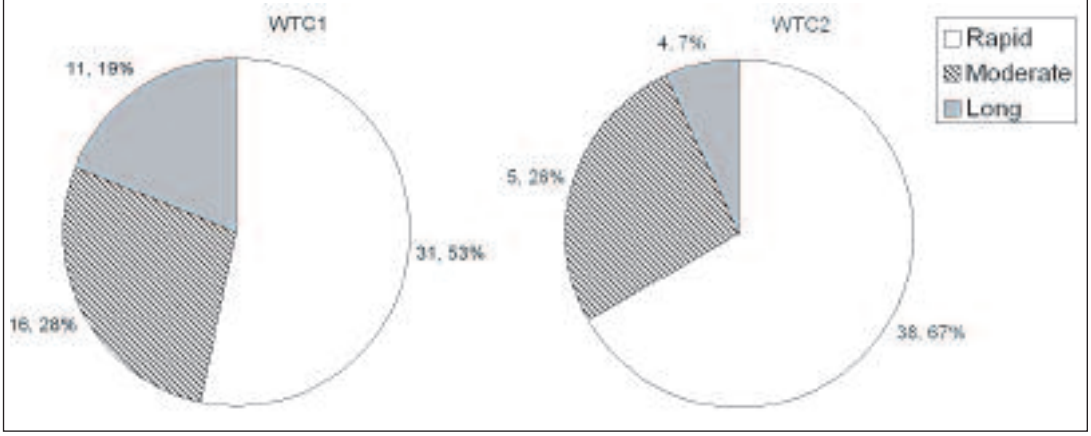
The majority of people in the database, for which we have response time data were categorised as rapid responders (i.e. up to 5 minutes), with 53% (31) of the occupants in WTC1 and 67% (38) of the occupants in WTC2 responding within 5 minutes of T1. This occurred in WTC2 despite several occupants reporting that they heard instructions over the PA system in WTC2 that there was no need to evacuate as WTC2 was secure.

Table 2: **Pre-evacuation times categorised as Rapid, Moderate or Long based on the total dataset of estimate response times**

Response time classification	WTC1	WTC2
Rapid (= 5 min)	31(53%)	38(67%)
Moderate (> 5 min and = 17 min)	16(28%)	15(26%)
Long (> 17 min)	11(19%)	4(7%)
Total	58	57

On the whole it was noted that occupants in WTC2 had shorter response times than those in WTC1. Analysis of the data suggests that this may have resulted from occupants in WTC2 having better knowledge of the event than those in WTC1 (see Section 6.10). More generally we find that most occupants began moving relatively quickly. However, some occupants spent considerable time involved in activities prior to beginning their evacuation. The longest response times identified within the database for occupants from WTC2 was 45 minutes (2% of occupants in database) while for WTC1, the longest reported response time was 74 minutes (5% of occupants in database). While it is difficult to generalise due to the lack of data, the rapid response times of occupants in WTC2 relative to WTC1 may have contributed to the smaller death toll experienced in WTC2.

Figure 5: **Rapid, Moderate or Long responders**



An attempt was made to determine whether or not the speed of response was related to occupant location. Of the 115 people providing response time information, 102 occupants also provided initial location information (54 from WTC1 and 48 from WTC2). In WTC1, 97% of the data came from people located below the impact zone, while in WTC2, 22% of the data came from below the impact zone.

Table 3: **Summary of fast, moderate or long responders grouped by location relative to each tower's IMPACT ZONE**

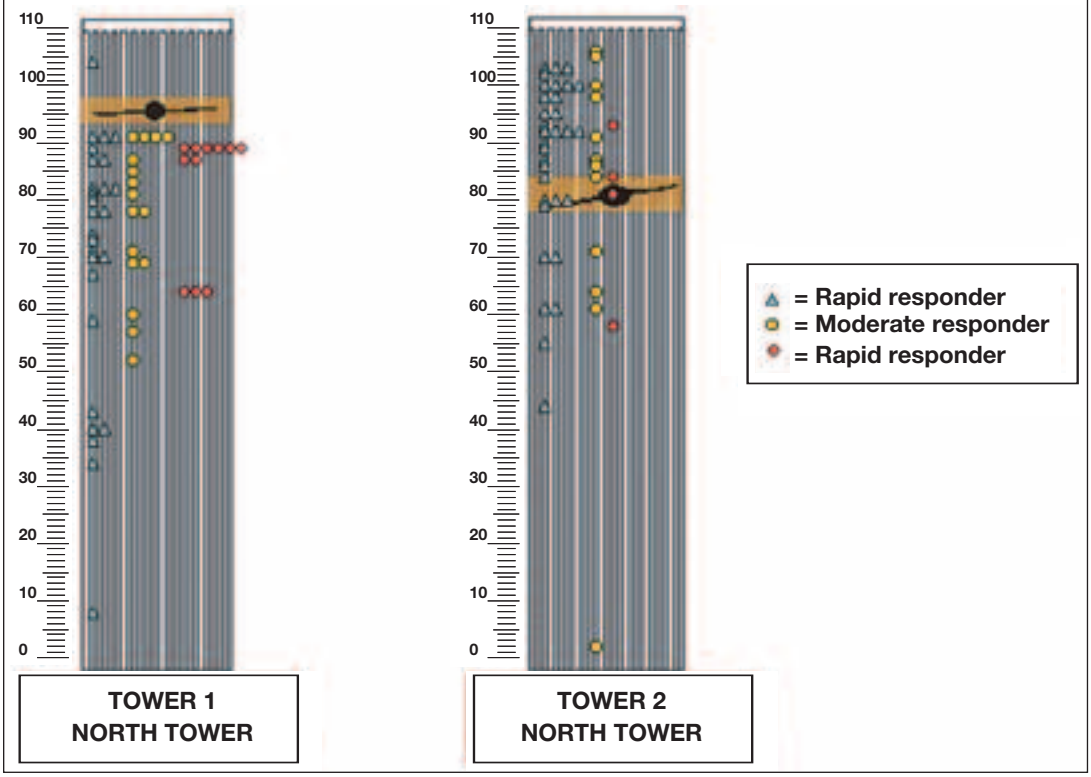
	WTC1			WTC2		
Grouping	**Rapid**	**Moderate**	**Long**	**Rapid**	**Moderate**	**Long**
Total	27[50%] (100%)	16[27%] (100%)	11[20%] (100%)	32[67%] (100%)	12[75%] (100%)	4[100%] (100%)
Above	1[2%] (4%)	No data	No data	21[44%] (66%)	8[50%] (67%)	1[25%] (25%)
In	No data	No data	No data	5[10%] (16%)	No data	2[50%] (50%)
<10 below	6[11%] (22%)	6[10%] (38%)	8[15%] (73%)	2[4%] (6%)	1[6%] (8%)	No data
10-20 below	8[15%] (30%)	4[7%] (25%)	No data	2[4%] (6%)	2[13%] (17%)	No data
the rest	12[22%] (44%)	6[10%] (38%)	3[5%] (27%)	2[4%] (6%)	1[6%] (8%)	1[25%] (25%)

[ ] = percentage of total known occupants, ( ) = percentage of response category

Depicted in Figure 6 is a schematic showing the location of occupants with known response time data. These figures suggest that there is a bias in the data for people from the upper in both buildings. In WTC1, 60% of the accounts (providing response time data and location) originate from the first 20 floors below the impact zone and in WTC2, 77% of the accounts come from within or above the impact zone. From the journalists point of view, these people provided the most interesting stories and so they focused their attentions on these people. Unfortunately, this does not allow a reliable analysis of location and response time distribution to be conducted.

However, the data suggests that the majority of lengthy response times in WTC1 originate from occupants located on the 10 floors below the impact zone. Indeed, 8/11 (73%) of the long pre-evacuations and 6/16 (38%) of the moderate pre-evacuations came from occupants initially located on one of the 10 floors below the impact zone. It is also interesting to note that on average, occupants located on the 10 floors below the impact zone generally undertook more actions during their pre-evacuation than occupants located elsewhere in the tower (see Table 4).

Figure 6: **Location and frequency of rapid, moderate or long response times**



In WTC2 long, moderate and rapid response times were evident throughout the tower. However, it was noted that in WTC2, 70% of the occupants located in or above the impact zone (for which we have both response time and location data) were classed as rapid responders. This represents 54% of the people in WTC2 for which we have data.

Table 4: **Number of actions reported in WTC1 by area (survivors and fatalities)**

	Location of occupants relative to impact zone				
	Above	**In**	**< 10 below**	**10-20 below**	**All others**
Number of reports	1	No data	15	7	22
Average number of actions	2	No data	4.3	1.6	2.5
Minimum number of actions	2	No data	1	1	1
Maximum number of actions	2	No data	12	4	13

Unfortunately, it should be noted that the nature of this data does not allow any meaningful generalisations to be made concerning the relationship between location and response time.

6.2 NATURE OF ACTIVITIES UNDERTAKEN IN PRE-EVACUATION PHASE

In this section we examine the actions performed by the occupants during the pre-evacuation phase. This is measured from the impact into WTC1.

The *actions* performed by individuals represent purposive tasks typically undertaken to confront the hazard, seek shelter, gather information or to flee. These actions were categorised into seven broad action classes which themselves can be further broken down into sub-action classes (see section 6.6). The seven main class actions are defined as follows:

1. Confront the hazard such as, *collect a fire extinguisher*.
2. Seek temporary refuge such as, *hide under desk*.
3. Gather/provide information such as, *look out the window or speak to a colleague*.
4. Receive/provide assistance such as, *rescue trapped colleague(s)*.
5. Prepare for the physical act of escape such as, *collect belongings*.
6. Extreme Behaviour or to panic and behave in an irrational manner.
7. Do nothing at all.

Confront the hazard involves occupants attempting to battle the fire in some way. Given the size of the hazard in the WTC disaster this type of behaviour would take on a local context and perhaps involve someone operating a fire extinguisher.

Seek temporary refuge behaviour may occur as occupants were not immediately aware of the details of event. Early on, some people may perceive a building rocking to be caused by an earthquake and so may seek shelter under desks or in doorways. In addition this behaviour encompasses a conscious decision not to evacuate if the occupant sought refuge in a perceived place of safety.

Gather/provide information refers to occupants collecting information concerning the unfolding event, perhaps to aid in their evacuation decisions. This may involve voice communication with colleagues, moving to inspect damage, making telephone calls or using emails.

Receive/provide assistance represents behaviours in which occupants provide or are provided with some form of physical assistance. This encompasses behaviour such as helping others to walk, providing water bottles, or returning to an office to physically assist a trapped occupant.

Prepare for the physical act of escape refers to behaviours in which occupants gather items or help other occupants in preparation for their evacuation. This behaviour includes things such as, collecting water bottles, ripping clothing to make face masks, gathering torches or fire extinguishers, collecting belongings or instructing others to leave.

Extreme Behaviour is a manifestation of panic and is taken here to be a state in which the occupant describes themselves as being at the extreme of anxiousness and arousal ***WHILE*** engaged in maladaptive, useless or destructive behaviour to self or others. This can involve individualistic competitive behaviour of moving directly to the exit (productive and adaptive for self) but unproductive and maladaptive for other occupants if the movement specifically disregarded other occupants, thereby

raising the level of danger to them. Examples of this would be deliberate pushing, fighting and displacement of others in order to access an exit before others. This behaviour also includes the abandonment of pre-emergency charges for self preservation. Panic is therefore self-destructive and self-obstructive non-evacuation of an *active* nature, and/or evacuation, but involving pushing, fighting, displacement or desertion which is constructive to self but destructive and obstructive of other occupants. Anxiety, shakes and terror are characteristics which would be included in the judgement of panic, but panic would not be included in anxiety, shakes and terror, as occupants can experience these but still act purposefully for self and judiciously in relation to others.

Table 5: **Summary of action frequency**

		Frequency	
Category	**All**	**T1**	**T2**
Gather provide/information	148 [55%]	75 [53%]	73 [58%]
Prepare or prepared for evacuation	93 [35%]	45 [32%]	48 [38%]
Offer or offered assistance	13 [5%]	9 [6%]	4 [3%]
Seek shelter	12 [4%]	11 [8%]	1 [1%]
Ignore events	1 [0%]	1 [1%]	0 [0%]
Confront Hazard	0 [0%]	0 [0%]	0 [0%]
Extreme Behaviour	0 [0%]	0 [0%]	0 [0%]
Total	267 [10%]	141 [15%]	126 [4%]

It is essential here to distinguish between the above definition of *Extreme Behaviour* and the common usage of the term *Panic* which may include behaviour such as running and yelling and feelings of anxiety and fear. It is not uncommon to find survivors describing themselves and others as panicking when their behaviour was probably intelligent, productive anxiety or the shaking and fear/terror which would rapidly promote escape urgency (also intelligent under disastrous conditions). Whilst behaviours such as calm, anxious, fearful, shaking and terrified are incontrovertible, the labelling of these people as 'panicking' is contentious.

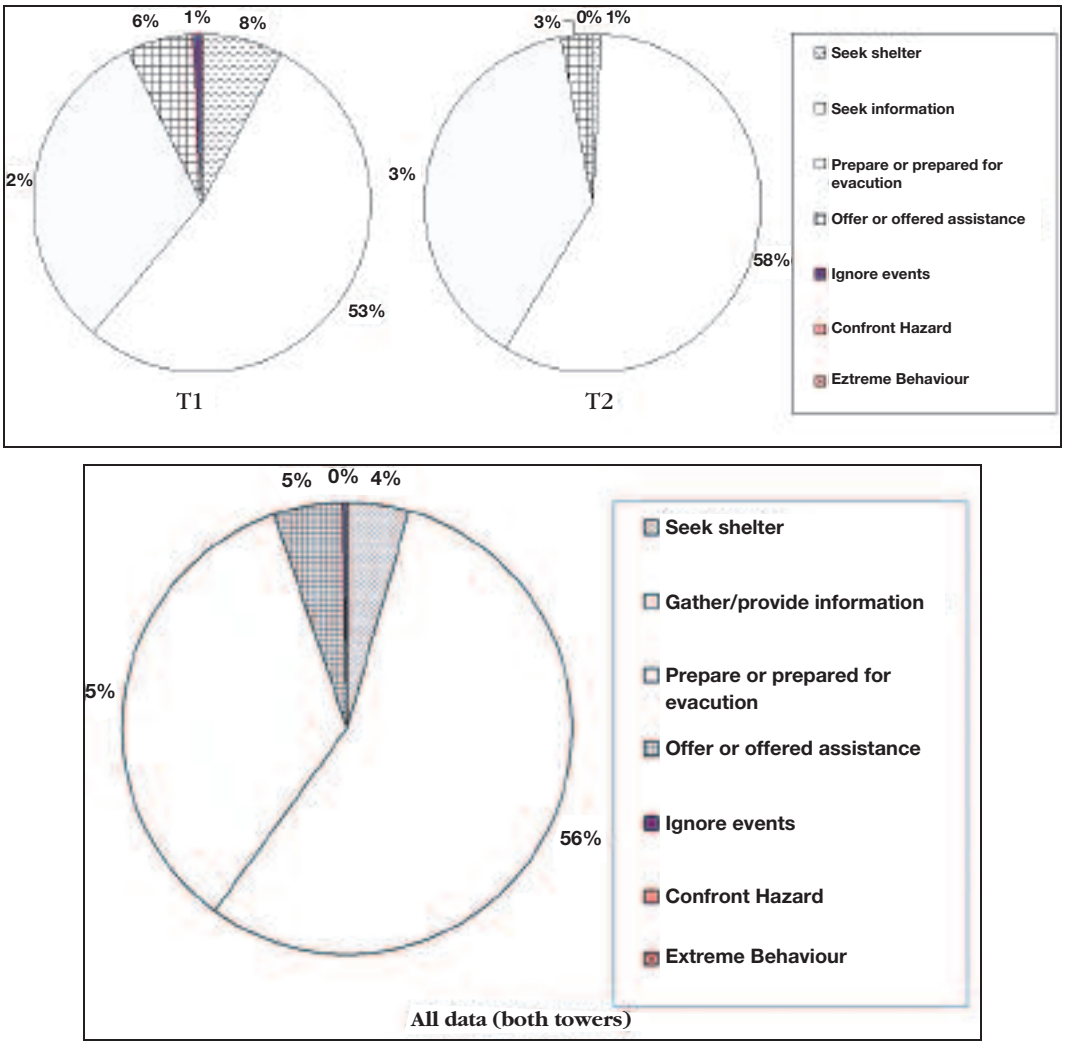
An example of an explicit self description of panic from the ground floor of WTC2 which amounts to an incorrect labelling of behaviour is as follows:

> *'I was in the concourse level when the first plane struck. In my store all I heard was this 'whush' sound, a couple of clanks, and then this mass of people including myself running from right to left in such a panic'.*
>
> [Experiences 2058-2066]

This occupant appears to suggest the running 'in such a panic' was aimless not directed, by a de-individuated 'mass'. This despite his specifying the crowd's movement direction, therefore the action must have been reasoned not blind. Also he equates the intelligent behaviour of trying to get to the exits on the right as quickly as possible with some kind of unintelligent stampeding, and uses the irrational notion of panic motivation interchangeably with the entirely rational motivation of escape urgency.

The use of press accounts as the basis of this analysis makes the task of assessing the reported behaviours all the more difficult as it is not possible to probe deeper into the reported behaviours. In this section we only consider described personal behaviour which can be interpreted as classic panic behaviour.

Figure 7: **Occupant actions in each tower and combined over both towers**



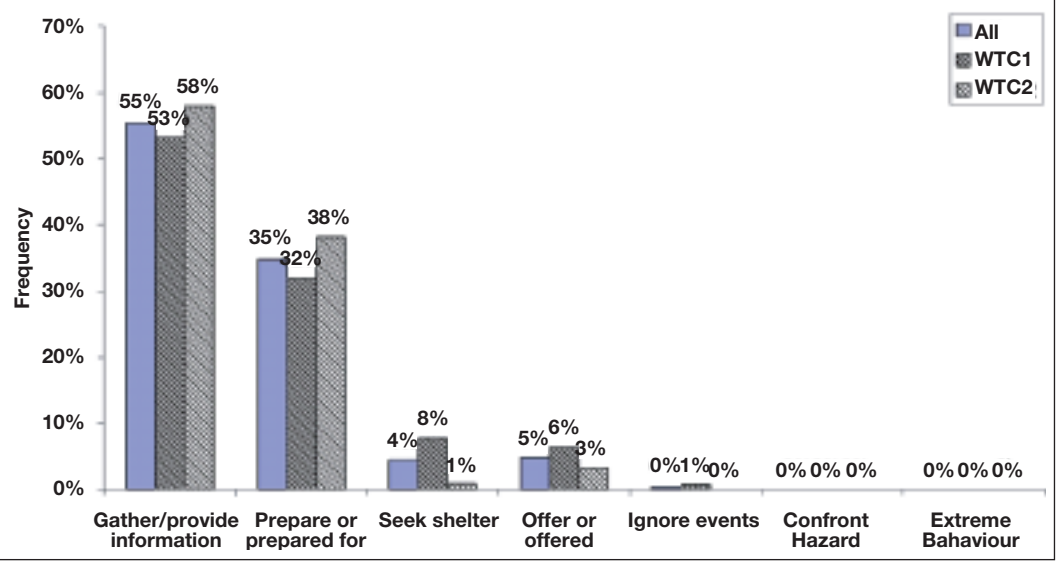
The *'do nothing'* action category represents occupants choosing to ignore the event and carry on with the activities they were involved with before the disturbance. This includes things such as, occupants hearing a noise but not investigating but carrying on working and equally occupants that may have investigated the disturbance but decided to ignore it returning to their normal work. This should not be confused with behavioural inaction or negative panic (see section 6.6).

Using these categories it is possible to interrogate the database to determine the frequency of each of these classes of actions. We have limited this analysis to include survivor behaviour. In total 124 occupants supplied pre-evacuation experiences and survived. Of these, 94/124 (76%) occupants detailed at least one action during their pre-movement. A further 19/124 (15%) occupants described leaving immediately and reported no pre-evacuation actions at all. The remaining 11 accounts supplied experiences but it could not be determined whether they performed any actions.

Of those that reported actions the results (see Table 5) indicate that gather/provide information was reported most frequently and represents 55% of all of the actions reported during pre-evacuation (see Table 5, Figure 7 and Figure 8). The next most frequently reported action was preparing for the evacuation itself. This accounted for approximately 35% of reported actions. Offering assistance and seeking shelter was reported at minor frequencies (4% and 5% respectively). Only one instance of an occupant completely ignoring the event was found within the database and reports of occupants confronting the fire was not reported at all. No examples of occupants behaving in an extreme manner could be found in the database.

If we examine the frequencies of reported actions across the two towers we note that the *gather/provide information* frequency is higher in WTC2 than WTC1 and that the percentage *seeking shelter* and *offering assistance* are both lower in WTC2 than in WTC1. This is possibly due to WTC2 being struck after WTC1, as a consequence a number WTC2 occupants began to evacuate prior to WTC2 being struck and so avoided dangerous post impact conditions.

Figure 8: **Breakdown of specific actions as a percentage of the total number of actions**



No accounts of *Extreme Behaviour* or behaviour that fits the academic view of 'panic' were reported by the survivors. On the whole people described their behaviours as being rational in the face of the extreme event that they were involved in. The fact that the *gather/provide information* category is the dominant reported action is significant as the requirement for this action could be removed if occupants could be provided with appropriate information. Reducing the need for gathering information may assist in reducing response times and overall evacuation times. Improved communication systems and procedures for disseminating information will allow occupants to more rapidly make appropriate evacuation decisions.

6.3 AVERAGE NUMBER OF ACTIONS REPORTED BY OCCUPANTS

In the previous section the frequency of performing specific actions was reported. In this section the number of actions reported by each occupant is investigated. It should be noted that the length of occupant accounts varied considerable. Some comprised of only a paragraph whereas others ran to several pages. This variation in the quality of available data seriously limited attempts at quantifying the number of actions undertaken by individuals. Indeed, the length of the account is undoubtedly related to some degree to the number of actions reported by an occupant. Thus, the data and analysis presented here should not necessarily be taken as representative of the incident.

From the available data, it is apparent that some occupants undertook a number of tasks before evacuating whilst others undertook just one or two. For example below is an extract from an occupant statement that provided a good account but undertook only one action (being instructed to leave [underlined]):

> *"On September 11, Peter Trombetta heard pipes clanging on the 91st floor of the South Tower and saw the lights flickering. His first thought was that it was caused by the construction that had been going on for months on the floor above him. Trombetta didn't have a window and his work area faced away from the North Tower. The first plane had hit at 8:46 a.m., and he didn't know it. "Within a minute, John came down the aisle saying, 'Everybody up and out,'" Trombetta recalls. "He didn't tell us why so as not to panic us. I kidded him that I had to get my plot plans I had just printed. He said, 'No, go.'"*
>
> [Experiences 1071-1074]

From the database it was possible to collate all of the actions undertaken during pre-evacuation for each occupant. These were then used to calculate an average number of actions, the standard deviation and a range. In total some 80 occupant accounts from WTC1 provided sufficient information to undertake this analysis (49 from survivors and 31 from fatalities). From WTC2, some 68 occupants (45 survivors and 23 fatalities) provided sufficient information.

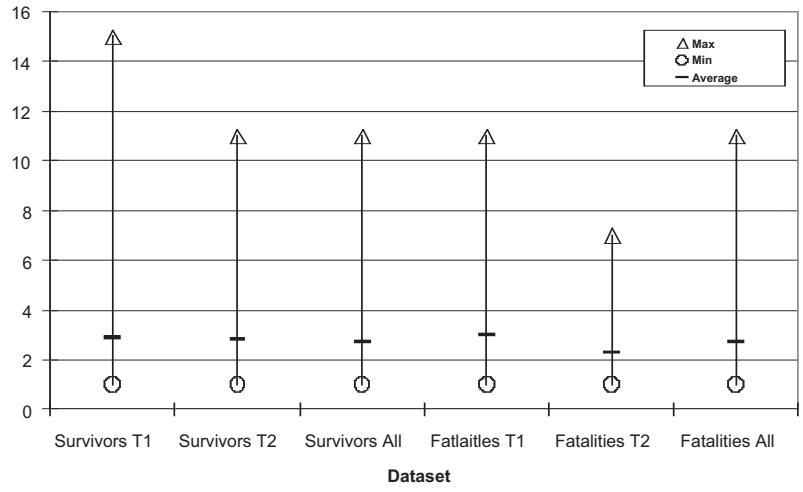
Table 6: **Summary of the number of actions undertaken by occupants during pre-evacuation**

	Survivors			Fatalities		
	#	Average [min-max]	Standard deviation	#	Average [min-max]	Standard deviation
T1	49	3 [1-15]	2.9	31	3 [1-11]	2.3
T2	45	3 [1-11]	2.3	23	2 [1-7]	1.7

[ ] range shown in brackets

The average number of actions reported by occupants within the towers was three (see Table 6). Counter intuitively it appears that survivors in WTC2 undertook on average *more actions* than fatalities. This anomaly is thought to originate from the nature of the accounts provided by fatalities. Accounts from fatalities were made over mobile phones and recorded by third parties typically a relative. The focus of these conversations was primarily to ascertain what actions should be taken (i.e. whether to evacuate or not or via which route) or to relay comforting messages to loved ones. In contrast the focus of survivor accounts was to explain what had happened to enquiring news paper reporters. The accounts from survivors tended to be much more detailed than those from occupants who did not successfully evacuate.

Figure 9: **Range of actions undertaken by survivors during pre-evacuation (see Table 6)**



Whilst the average number of reported actions is relatively small (on average three) some occupants reported as many as 15 actions (see Table 6 and Figure 9). If a frequency distribution of reported actions is plotted, it reveals that accounts which reported high numbers of actions represent outliers in the tail of the distribution (see Table 7 and Figure 10). The frequency distribution data shows that the vast majority 131 (88.5%) of occupants reported between 1-5 actions, whereas a small minority (5 or 3.3%) reported over 10 actions. In total 12 accounts reported between 6 and 9 actions. It is therefore extremely misleading to use the range as an indicative of the number of actions undertaken.

In summary, the data suggests that on average, occupants reported undertaking 3 actions prior to beginning their evacuation.

Table 7: **Frequency of reported actions per tower**

	WTC1		WTC2	
Number of actions	**Survivors**	**Fatalities**	**Survivors**	**Fatalities**
0	0	0	0	0
1	22	8	15	9
2	10	9	14	8
3	4	6	3	2
4	3	1	5	0
5	1	2	3	3
6	4	3	2	0
7	3	1	0	1
8	0	0	1	0
9	0	0	1	0
10	0	0	0	0
11	1	1	1	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	1	0	0	0

Figure 10: **Frequency distribution of actions undertaken by occupants in WTC1 (survivors and fatalities)**

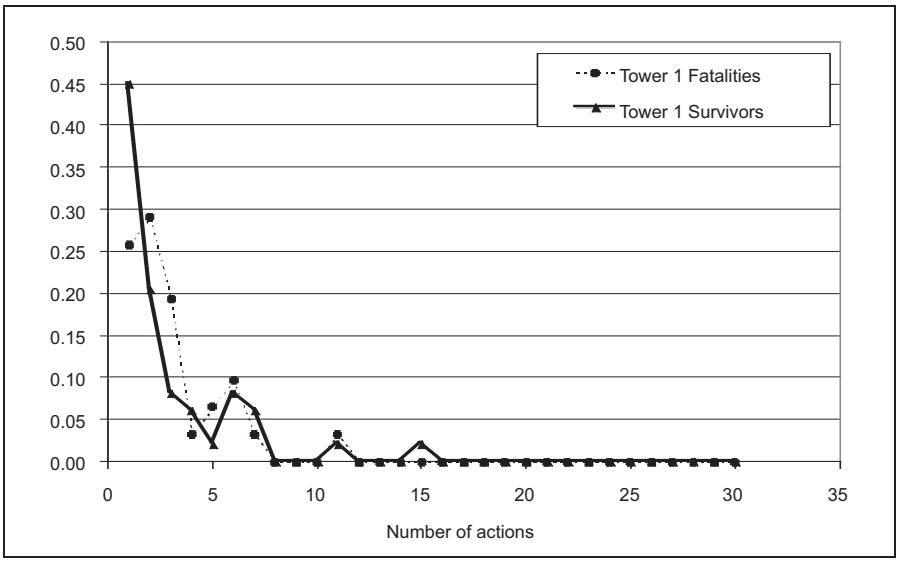
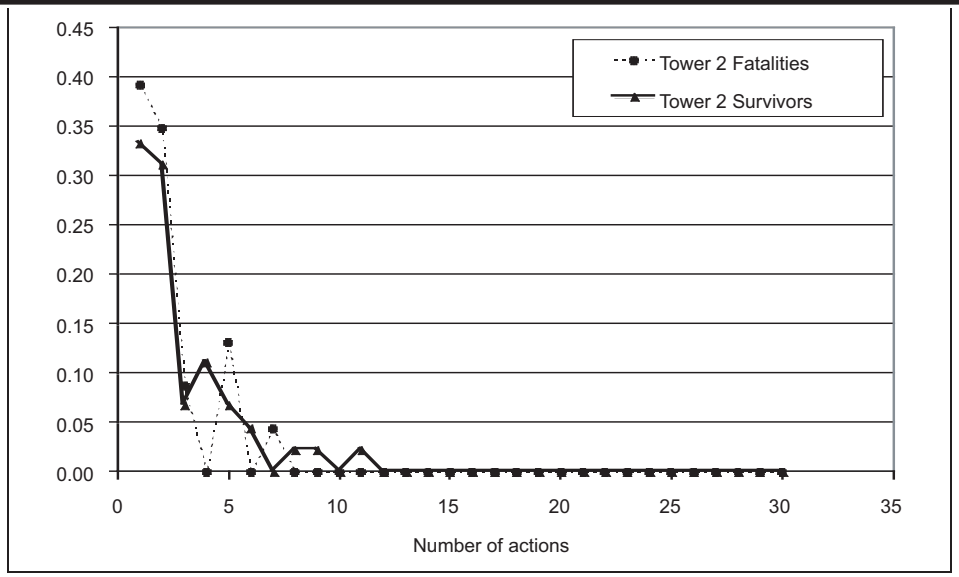


Figure 11: **Frequency distribution of actions undertaken by occupants in WTC2 (survivors and fatalities)**



6.4 ORDERING OF OCCUPANT ACTIONS

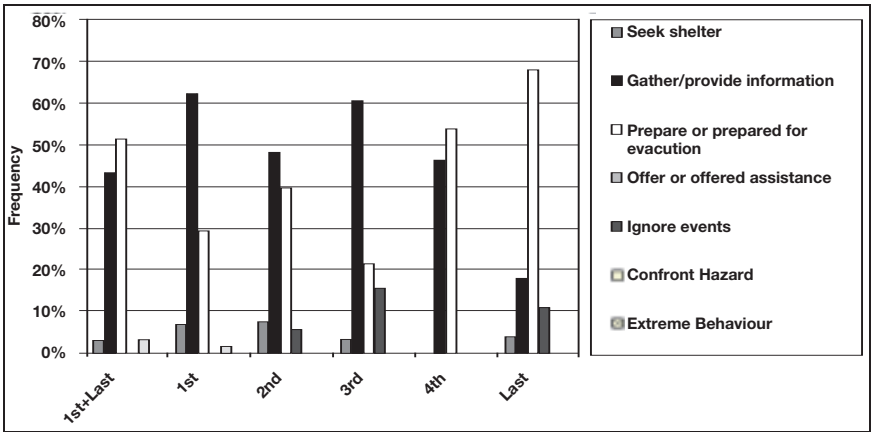
Within the database the order of occupant experiences was analysed to determine if there was any sequence to occupant actions during pre-evacuation. Given the limitations of the dataset, analysis was restricted to include occupants' *first, second, third* and *fourth* actions. In addition, the *last action* undertaken by an occupant is examined and where occupants undertook only one action their *first and last action*.

The data (see Table 8) suggests that *'gather/provide information'* constituted the most reported first (62%), second (48%) and third (61%) actions. However, preparing for evacuation was the most reported forth (54%) action. The last reported action were actions associated with *'preparing for evacuation'* in 68% of the reports within the database. Only 18% of reports represented seeking information type actions. The trend was not so clear for those occupants that only stated one action, i.e. occupants whose first action was also their last action. For these, actions were evenly distributed between *gather/provide information* (43%) and *preparing for evacuation* (51%).

Table 8: **Summary of action orders aggregated for both towers**

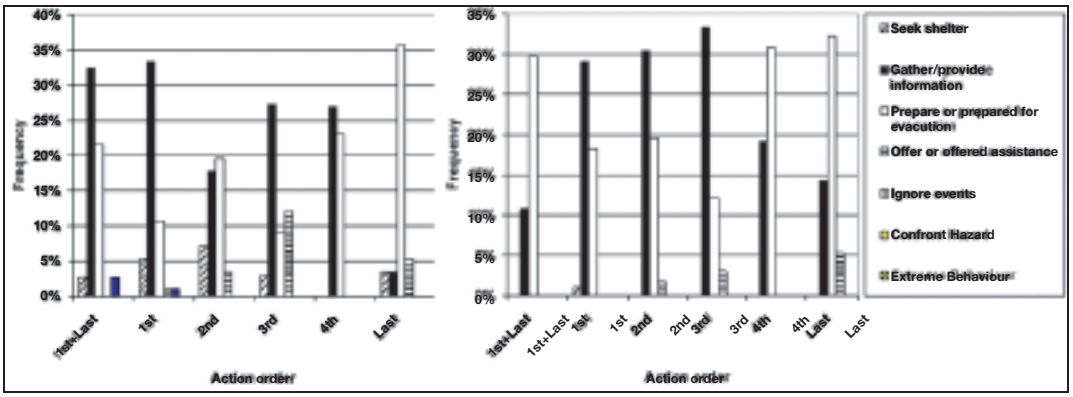
		1st+Last	1st	2nd	3rd	4th	Last
Both towers	*Seek shelter*	1 [3%]	6 [6%]	4 [7%]	1 [3%]	0 [0%]	2 [4%]
	Gather/provide information	16 [43%]	58 [62%]	27 [48%]	20 [61%]	12 [46%]	10 [18%]
	Prepare or prepared for evacuation	19 [51%]	27 [29%]	22 [39%]	7 [21%]	14 [54%]	38 [68%]
	Offer or offered assistance	0 [0%]	1 [1%]	3 [5%]	5 [15%]	0 [0%]	6 [11%]
	Ignore events	1 [3%]	1 [1%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Confront Hazard	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Extreme Behaviour	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Total	37 [100%]	93 [100%]	56 [100%]	33 [100%]	26 [100%]	56 [100%]
WTC1	*Seek shelter*	1 [3%]	5 [5%]	4 [7%]	1 [3%]	0 [0%]	2 [4%]
	Gather/provide information	12 [32%]	31 [33%]	10 [18%]	9 [27%]	7 [27%]	2 [4%]
	Prepare or prepared for evacuation	8 [22%]	10 [11%]	11 [20%]	3 [9%]	6 [23%]	20 [36%]
	Offer or offered assistance	0 [0%]	1 [1%]	2 [4%]	4 [12%]	0 [0%]	3 [5%]
	Ignore events	1 [3%]	1 [1%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Confront Hazard	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Extreme Behaviour	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Total	21 [59%]	43 [52%]	23 [48%]	16 [52%]	13 [50%]	25 [48%]
WTC2	*Seek shelter*	0 [0%]	1 [1%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Gather/provide information	4 [11%]	27 [29%]	17 [30%]	11 [33%]	5 [19%]	8 [14%]
	Prepare or prepared for evacuation	11 [30%]	17 [18%]	11 [20%]	4 [12%]	8 [31%]	18 [32%]
	Offer or offered assistance	0 [0%]	0 [0%]	1 [2%]	1 [3%]	0 [0%]	3 [5%]
	Ignore events	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Confront Hazard	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Extreme Behaviour	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]
	Total	15 [41%]	44 [48%]	29 [52%]	16 [48%]	13 [50%]	29 [52%]

Figure 12: **Comparison of action ordering for both towers**



This analysis suggests a trend in which occupants were gathering/providing information early during their pre-evacuation and then preparing for evacuation towards the end of their pre-evacuation phase. These trends are more clearly seen in Figure 12 and Figure 13. The white bars (indicating evacuation preparation type actions) increase as occupants' pre-evacuation advances. Conversely the black bars (indicating gather/provide information type actions) decease as occupants' pre-evacuation advances.

Figure 13: **Action ordering for WTC1 and WTC2**



WTC1 WTC2

These observations are considered significant as they suggest a trend in the ordering of occupant actions during pre-evacuation. Reported initial actions tended to involve seeking information, whereas reported final actions tended to involve preparation to evacuate. Again this serves to highlight the need to provide occupants with immediate and good quality information so that they do not have to waste precious minutes determining the nature of the event before beginning their evacuation.

6.5 PRE-EVACUATION ACTIONS AND RESPONSE TIMES

This section examines the relationship between the number of actions that occupants performed and the length of their response time (pre-evacuation time). The data set is smaller than used in the actions analysis presented previously as it was not possible to determine a response time for all occupants who specified pre-evacuation actions. Presented in Table 9 is the average number of actions as a function of response time. The data, while inconclusive, suggests a weak tendency for longer response times to be associated with more actions.

Table 9: **Average number of reported actions as a function of the estimated response time class**

	Rapid Response time		Moderate Response time		Long Response time	
	Average Number of actions	#	Average Number of actions	#	Average Number of actions	#
All	1.5	55	1.4	38	2.0	13
Survivors	1.4	39	1.4	21	1.5	7
Fatalities	1.8	16	1.5	17	2.5	6

6.6 A MORE DETAILED BREAKDOWN OF THE FREQUENCY OF SPECIFIC ACTIONS

In this section we examine in more detail the specific actions that comprise each of the seven broad action classes identified in Section 6.2. A total of 16 sub-category actions were defined as follows:

Seek information This refers to an occupant physically moving to gain some information i.e. moving to the window to look outside or leaving a desk to check the hallways. An example from the database is provided by experience [1221]: *"'I looked out the window just a few feet away to see glass, thousand of sheets of paper, and large metal pieces raining down,'".*

Instruct others This refers to an occupant issuing some form of instruction to another occupant i.e. issuing an instruction to others to "evacuate now" or for others to "stay where you are". An example from the database is provided by experience [300]: *"I continue yelling that we have to get out of there but no one listens."*

Instructed This refers to an occupant receiving some form of instruction from another occupant i.e. receiving an instruction from another to "evacuate now" or to "stay where you are". An example from the database is provided by experience [208]: *"Carol was yelling at a young lady making a telephone call in the hallway to get off the telephone and come with us. She didn't come.."*

Give information This action refers to an occupant communicating some information about the event which is occurring i.e. "I think a plane has hit the building" or "I have checked and the lifts are not working". This action only refers to local verbal communication. An example from the database is provided by experience [3206]: *"I ran around the floor yelling to everybody, 'A plane just crashed into the building. We have to get out of here. We have to get out of here.' I ran all around the floor and told everybody."*

Receive information This action refers to an occupant receiving some information about the event which is occurring i.e. being told by someone else that a plane has hit the building or being told that the lifts are not working. This action only refers to local verbal communication. A suitable example from within the database comes from experience [2422]: *"Then someone yelled that he'd found a stairwell where it was safe. Only the elevator was burning."*

Make call This action refers to an occupant making a telephone call. A suitable example from within the database comes from experience [355]: *"I called my wife and told her, 'You know, you won't believe this but Tower One has been hit. We are fine where we are. Relax, turn on the TV, there is a developing story there, find out what's happening.'"*

Receive call This action refers to an occupant receiving a telephone call. A suitable example from within the database comes from experience [154]: *"Carol Roberts's friend, who is a police officer, called her and said to get out of the building because there was an explosion."*

Collect item This action refers to an occupant collecting an item i.e. a briefcase or a mobile phone. A suitable example from within the database comes from experience [149]: *"I started packing my briefcase with my laptop and my files and stuff, and he stood there. He kept yelling at me. I was the last one to leave the room. He wouldn't leave until I left,"*

Offer assistance This action refers to an occupant providing assistance to another occupant i.e. an occupant climbing over debris to rescue another occupant or an occupant helping another to walk. A suitable example from within the database comes from experience [3246]: *"We shifted John over from his wheelchair to the evacu-chair."*

Offered assistance This action refers to an occupant receiving assistance from another occupant i.e. being helped to walk or being rescued from under some debris. A suitable example from within the database comes from experience [102]: *"'Fred was calling out 'who is here?' Christine answered for the both of us "Yvette and Christine are here, what do we do?'"*

Prepare for evacuation This action refers to an occupant preparing for evacuation e.g. collecting a fire extinguisher or ripping a shirt to make a mouth mask. A suitable example from within the database comes from experience [81]: *"I off my tee shirt and ripped it into 3 pieces. Soaked it in water.*

Prepare others for evacuation This action refers to an occupant being the recipient of some preparatory act of preparation prior to evacuation. i.e. receiving a bottle of water or a piece of ripped clothing to use as a mouth mask. A suitable example from within the database comes from experience [82]: *"Gave 2 pieces to my friends. Tied my piece around my face to act as an air filter."*

Seek shelter This action refers to an occupant seeking physical shelter i.e. hiding under a desk or retreating to a protected area and waiting for rescue or to decide what to do. A suitable example from within the database comes from experience [94]: *"I crawled over to my boss's cubicle to grab onto her".*

Extreme behaviour This action refers to a person performing some form of classic panic behaviour e.g. stampeding crowd knocking down everyone in its wake (see Section 6.2 for a more complete definition).

Confront hazard Confronting the hazard would involve occupants attempting to battle the fire in some way. Given the size of the hazard in the WTC disaster this type of behaviour would take on a local context and perhaps involve someone operating a fire extinguisher. No instances of this behaviour were found during pre-evacuation.

Ignore events This action refers to the person choosing to ignore the event and carry on working. An example of this is a computer technician in a air sealed server room hearing something but ignoring it and carrying on working [Experience 3458]

Every experience that represented an action was attributed to one of these action classes and sub-categories during the data input process. The exact composition of each of the broad classes can be seen below:

1. **Seek information**
   a) Seek information
   b) Receive information
   c) Give information
   d) Make call
   e) Receive call
2. **Prepare or be prepared for evacuation**
   a) Instructed
   b) Instruct others
   c) Collect item
   d) Prepare for evacuation
   e) Prepare others for evacuation

3. **Offer or be offered assistance**
   a) Offered assistance
   b) Offer assistance
4. **Seek shelter**
   a) Seek information
5. **Confront the fire**
   a) Confront the fire
6. **Ignore Event**
   a) Ignore the event
7. **Extreme Behaviour**
   a) Extreme behaviour

Using these categories the frequency of each of the actions occurring during occupant pre-evacuation has been calculated from the database (see Table 10, Figure 14 and Figure 15). From the data it can be seen that approximately 30% of actions reported during the pre-evacuation phase involved *seeking some sort of information* (for example, looking out of windows, checking hallways or switching offices). The second most reported action involved occupants *receiving some information* about the event from someone else (14%) – occupants actually *giving information* was reported with reduced frequency (5%). The third and forth most common reported action category was occupants *issuing* (14%) or *receiving* (12%) *evacuation instructions* (for example, *"evacuate now"*, *"move to the stairs now"*). Other frequently reported actions were making or receiving telephone calls (10% and 3% respectively) and collecting personal items (11%). Less frequently reported actions were *offering or receiving assistance* (0.8% and 4.7% respectively), *preparing for evacuation* or *preparing others* (3.4% or 0.4%) and *seeking shelter* (3.4%).

As noted earlier, there were no reports of personal actions that could be classified as fitting our definition of *extreme behaviour* (0%). Whilst occupants did not report behaviours of their own that could be classed as *extreme behaviour* or 'panic', many occupants witnessed behaviour of others that they defined as panic, some of which could be classed as *extreme behaviour*. Within the database there are five observations of behaviours that could be classified as extreme behaviour. Three of these represented a so called 'stampede' in which the stampeding crowd displayed disregard for others. The other two represented an episode of behavioural inaction or negative panic. Negative panic is typically witnessed in high stress evacuation situations and involves the occupant seemingly ceasing to take any action [3]. From occupant accounts it appears that this behaviour was witnessed during the WTC evacuation to some extent.

The following three experiences are the accounts that comprised observations of extreme behaviour involving stampede.

> *"After what seemed like an eternity the building settled and the evacuation began in earnest. Except people were panicking and a stampede started and they were running each other down."*
>
> [Experience 601]

> *"At this time I saw a person coming up from the 77th floor who was in total shock and not answering us as we questioned him going in the opposite direction."*
>
> [Experience 831]

"While everyone ran frantically to search for a safe location, a stampede of people ran towards me and knocked me into a steel barricade. Andrew quickly lifted me up when in the distance was the alarming image of people jumping from windows to their deaths."

[Experience 1195]

The following example describes an episode of behavioural inaction or negative panic,

"Everybody made for the stairs except for Hong Zhu, an investment banker, who was frozen with fear. He told the others he would wait for help. Mr. Ramos cajoled him to the stairwell door."

[Experience 791]

"I remember the blank stares and zombie-like expression on one person I assume to be an AON manager who had an external office, and asking him to go into the 'staircase', which I think he did."

[Experience 790]

Table 10: **Summary of the frequency of each reported action category within the database**

	All	**WTC1**	**WTC2**
Seek information	72 [27%]	35 [25%]	37 [29%]
Receive information	33 [12%]	22 [16%]	11 [9%]
Collect belonging	29 [11%]	14 [10%]	15 [12%]
Instruct others	28 [10%]	12 [9%]	16 [13%]
Instructed by others	27 [10%]	11 [8%]	16 [13%]
Make call	24 [9%]	14 [10%]	10 [8%]
Give information	13 [5%]	4 [3%]	9 [7%]
Seek shelter	12 [4%]	11 [8%]	1 [1%]
Offer assistance	11 [4%]	7 [5%]	4 [3%]
Prepare for evacuation	8 [3%]	7 [5%]	1 [1%]
Receive call	6 [2%]	0 [0%]	6 [5%]
Offered assistance	1 [0%]	1 [1%]	0 [0%]
Prepared for evacuation	1 [0%]	1 [1%]	0 [0%]
Ignore events	1 [0%]	1 [1%]	0 [0%]
Confront hazard	0 [0%]	0 [0%]	0 [0%]
Extreme behaviour	0 [0%]	0 [0%]	0 [0%]
Total	268 [100%]	141 [100%]	127 [100%]

The word 'panic' was explicitly used to describe the behaviour of others in 19 accounts. Of these 10 described witnessing 'panic', for example:

> *"I was having problems with Teresa because she was panicking and hyperventilating and was about to pass out. We had to stop on one floor to let her rest and catch her breath for about 5 or 10 minutes."*
>
> [Experience 3410]

This account appears to be describing the effects of shock rather than panic. Another example describes the understandable and arguably rational response of extreme urgency displayed by occupants attempting to expedite their evacuation,

> *"When word came around to evacuate the second tower, there was panic. "People jammed the stairwells and the elevators were all over capacity. "We got out and just ran like there was no tomorrow. When we stopped to look back, there was a huge gaping hole"*
>
> [Experience 2391]

Another account gives no evidence of panic, but simply uses the term,

> *"It was filled with smoke and panicked people still trying to get out."*
>
> [Experience 1868]

Furthermore, there were 9 explicit mentions of the absence of panic in the description of the behaviour of occupants, for example,

> *"The evacuation was very orderly, people were great – no panic."*
>
> [Experience 593]

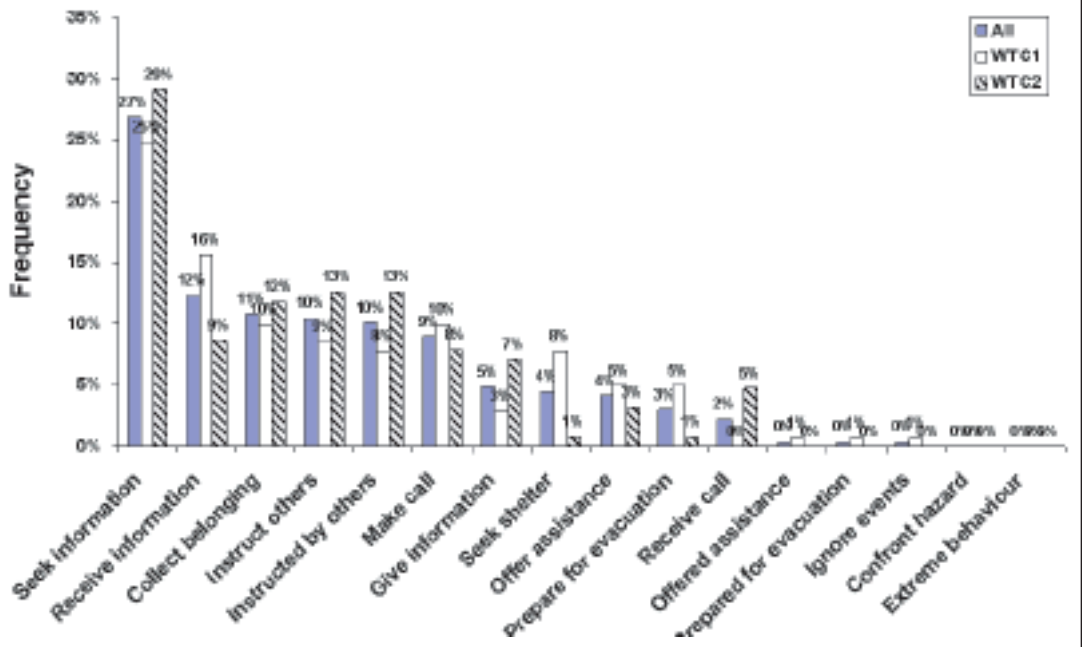
whilst another stated that,

> *"There were a large number of people in the stairwell already, people were moving two abreast. There was no apparent panic, but people were moving with a certain urgency"*
>
> [Experience 724]

Finally, other descriptions of the psychological state of occupants were reported and recorded in the database. Examining this revealed that 10 occupants reported that they were explicitly calm. Three of these came from occupants located above the impact zone and 1 from an occupant just below impact in WTC1. Two were from occupants in WTC2 evacuating after T2 impact. The following example was from an occupant located above the impact zone in WTC1,

> *"Then he said the floor was buckled. And he said it was getting really hot and hard to breath. His voice was actually very calm. It wasn't like someone calling up panicking."*
>
> [Experience 1726]

Figure 14: **Breakdown of specific actions as a percentage of the total number of actions**

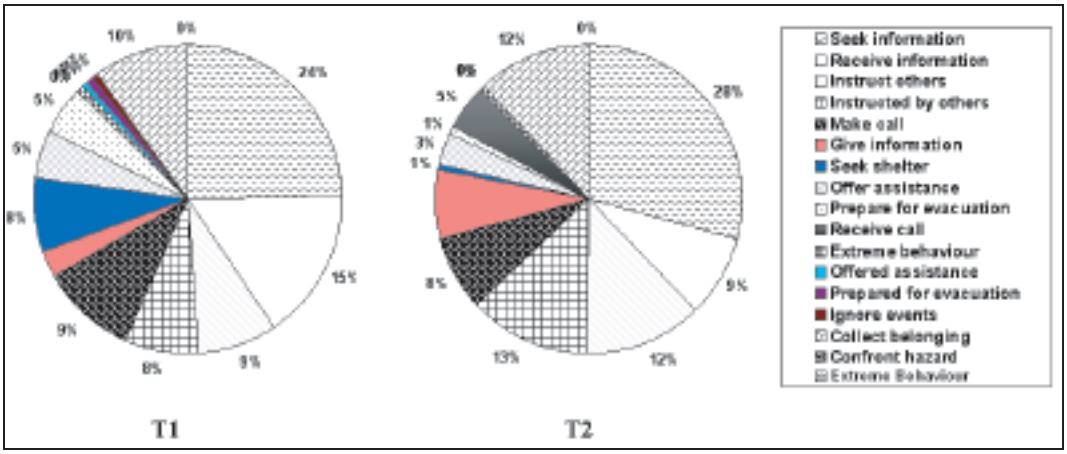


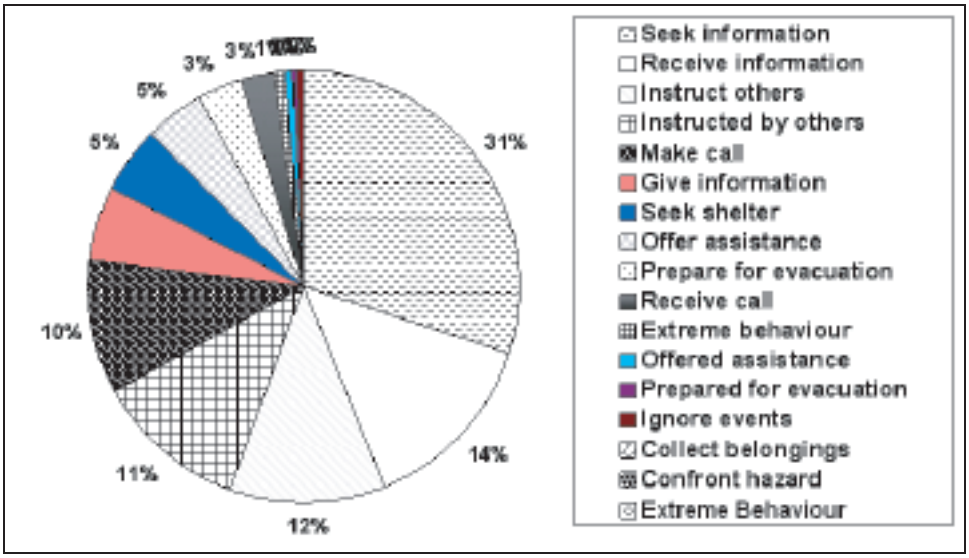
Many others specified a range of stress. This were categorised within the database as "scared" (20 reports), "confused" (3 reports), "terror" (5 reports), joking / laughing (7 reports), "nervousness" (5 reports), "shock" (6 reports), "screaming" (9 reports), "being not scared" (2 reports) or "worrying" (3 reports).

Whilst useful, it is apparent from the data that some of the categories represent the same types of actions but differentiate the role of the occupant in the action, i.e. they differentiate between being the *recipient* or *instigator* of an action. For example, *give* and *receive information* both represent a local communication of knowledge about circumstances inside or outside the tower. However one distinguishes the role of the reporter of information as the transmitter and the other category distinguishes the recipient of information as the receiver. In a general sense they both represent the occurrence of the same action, i.e. a local communication of information. Other actions that share this trait are to *offer* or *receive* assistance, to *prepare for* or to *prepare others* for evacuation, to *make* and to *receive* a telephone call and finally to *instruct* or to *be instructed* to do something.

The data was reanalysed such that actions are grouped according to their general type irrespective of whether a person instigated or was the recipient of the action. In doing so a view of the occurrence of these specific reported action types is generated. This tells us the frequency of specific actions being reported irrespective of the roles of people involved.

Figure 15: **Breakdown of specific actions as a percentage of the total number of actions**





Both towers

Using this scheme the 16 actions were compressed into 9 coarse categories. The actions *confront the hazard, do nothing* and *extreme behaviour* have been omitted as they were infrequently reported. The final 9 categories are presented below.

1 **Seek information** (i.e. physically move to acquire information yourself)
2 **Instruct or instructed by others**
   a) Instructed
   b) Instruct others
3 **Communicate locally** (i.e. communicate verbally)
   a) Receive information
   b) Give information
4 **Communicate remotely** (i.e. specifically telephone calls)
   a) Make call
   b) Receive call
5 **Collect item**
6 **Offered or be offered assistance**
   a) Offered assistance
   b) Offer assistance

7 Prepare self or others for evacuation
a) Prepare for evacuation
b) Prepare others for evacuation
8 Seek shelter
9 Extreme Behaviour

Based on these categories it is apparent that the general trends are maintained. *Seeking information* is still the most frequently reported action type during the pre-evacuation phase of the WTC evacuation (see Table 11, Figure 16 and Figure 17). Similarly the second most frequently reported action involved the *instructing of occupants. Local communication* accounted for approximately 17% of reported actions whilst *non-local communication* (i.e. those using telephones or emails) accounted for 11% of reported actions. *Collecting items* (i.e. belongings) represents 11% of reported actions within the database during pre-evacuation. All other actions were reported with only minor frequencies.

Table 11: **Summary of the frequency of each action category within the database**

	All	T1	T2
Seek information	72 [27%]	35 [25%]	30 [24%]
Instruct or instructed	55 [21%]	24 [17%]	22 [18%]
Communicate locally	46 [17%]	26 [18%]	25 [20%]
Communicate remotely	30 [11%]	14 [10%]	12 [10%]
Collect belonging	29 [11%]	14 [10%]	14 [11%]
Offer or offered assistance	13 [5%]	9 [6%]	8 [6%]
Seek shelter	12 [5%]	11 [8%]	9 [7%]
Prepare or prepared for evacuation	9 [3%]	8 [6%]	5 [4%]
Extreme Behaviour	0 [0%]	0 [0%]	0 [0%]
Total	266 [100%]	141 [100%]	125 [100%]

Figure 16: **Breakdown of specific actions as a percentage of the total number of actions**

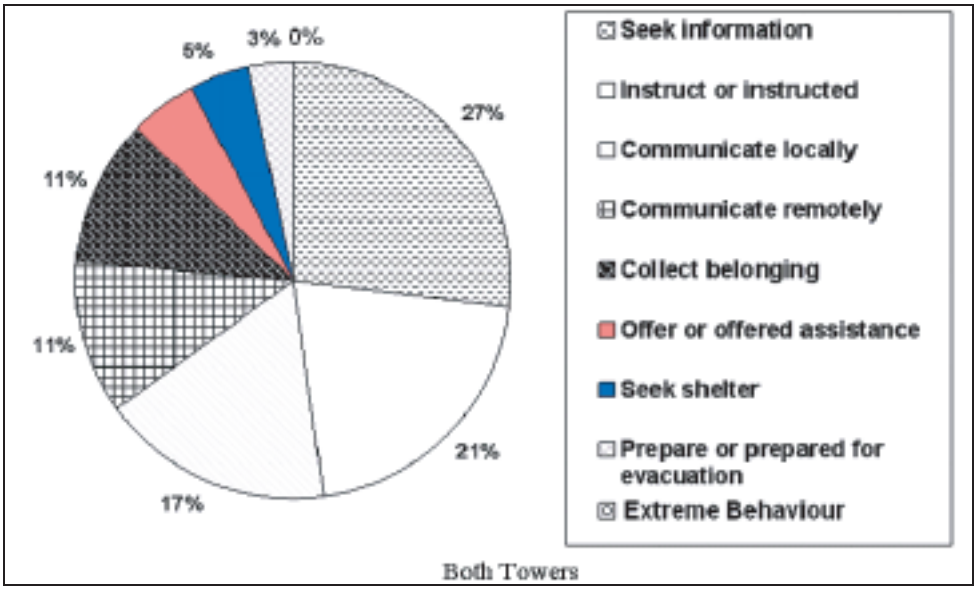
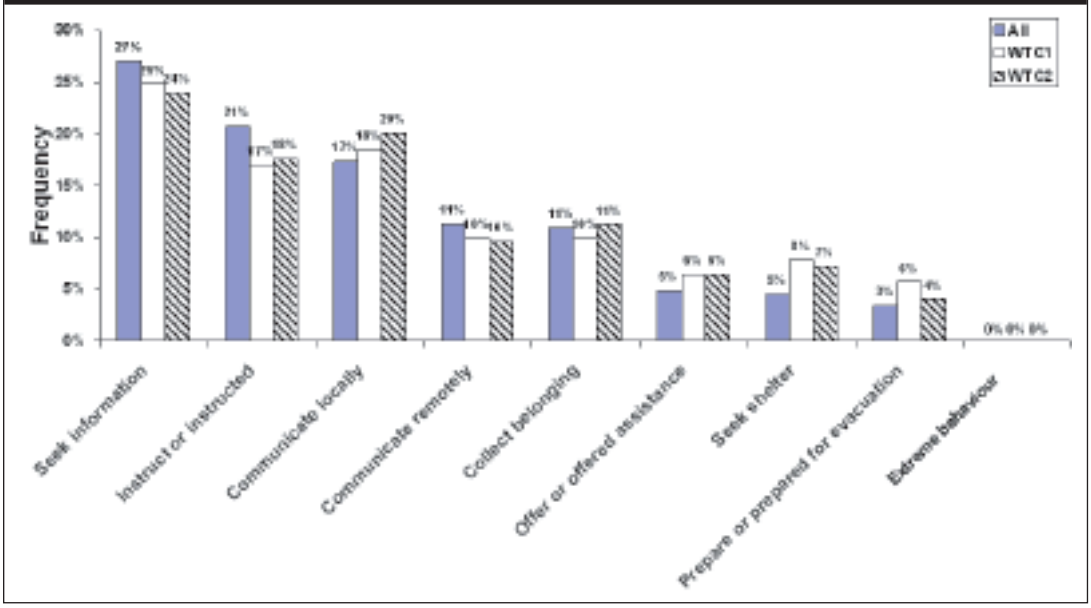


Figure 17: **Bar chart of the frequency of specific actions using the coarse categorisation**



If local and remote communication are grouped together it would constitute the most frequently reported action representing approximately 29% of reported actions. Thus communication *per se* should be viewed as the most common type of action reported during the pre-evacuation. If communication is combined with seek information then this class of action represents some 72% of the pre-evacuation actions. Clearly, the occupants are operating within an information deprived state. Again this serves to highlight the need to provide occupants with immediate and good quality information so that they do not have to waste precious minutes determining the nature of the event before beginning their evacuation. Providing reliable information to the occupants would be of great benefit to their decision making process and so speed up the evacuation process.

6.7 THE NATURE OF THE TELEPHONE CONVERSATIONS

Issues associated with Remote Verbal Communication are examined in this section. While engaging in telephone conversations is one means by which people can exchange information, it has the potential to slow occupant pre-evacuation and consequently increase their overall evacuation time. It is therefore important to gauge the frequency of telephone usage during emergency situations and understand the rationale behind telephone usage. Remote communication i.e. use of telephones, was frequently cited during pre-evacuation (the fourth most common action see Section 6.6) and with some frequency during evacuation itself.

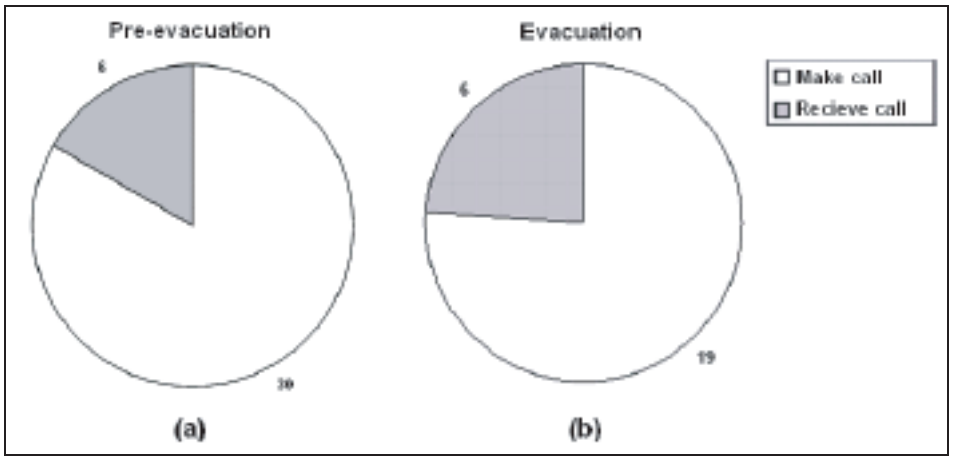
This analysis uses the population defined in the actions analysis (see Section 6.6). In this section survivors and fatalities are examined separately. The distinction between survivors and fatalities is necessary as many calls were made by occupants who were trapped on the upper floors and were unable to evacuate. Here we are primarily interested in the calls made by occupants that successfully evacuated. These came from 19 people, i.e. 19/94 (20.2%) of the population that stated actions and could have survived.

Table 12: **Summary of telephone conversations during PRE-EVACUATION and EVACUATION from BOTH towers**

		Telephone events		People involved	
		Pre-evacuation	Evacuation	Pre-evacuation	Evacuation
Survivors	**Make**	24	19	19	12
	Receive	6	6	4	3
	Total	30	25	23	15
Fatalities	**Make**	55	11	34	8
	Receive	21	2	12	2
	Total	76	13	46	10

In total 30 telephone usage actions were reported during pre-evacuation by occupants that successfully evacuated (see Table 12). Of these calls, 24/30 (80%) of the reported telephone conversations recorded in the database involved an occupant making a call, with only 6/30 (20%) of reported calls involving occupants answering an incoming call. This trend was also apparent during evacuation itself with 43/49 (87.8%) of reported calls were outgoing while 6/49 (12.2%) were incoming (see Figure 18).

Figure 18: **The number of calls MADE and RECEIVED by SURVIVORS during PRE-EVACUATION and EVACUATION**



The majority 22/30 (73%) of calls were made to locations outside of the building (see Table 13 and Figure 19). Calls to/from people located inside the towers were less frequent, representing only 27% (8/30) of the outgoing calls.

Below is an example account from a female occupant who was on the 64th floor of WTC1:

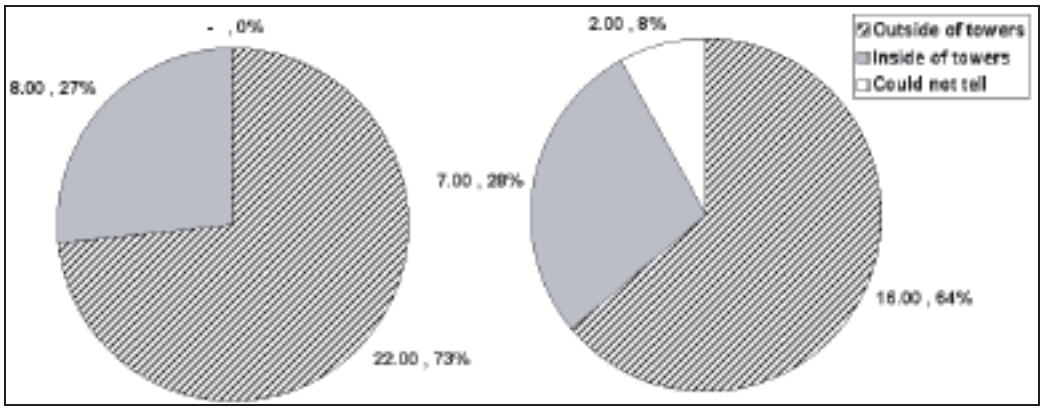
> *"Initially she was knocked off her chair by the impact. Curiously, although not scared, she moved to the window to view what had happened. Speculation in the office thought it was an aircraft impact. She is told to leave. She in turn goes to her colleague, who is engaged on the telephone, and instructs her to leave. She grabs some personal affects and begins to leave. En route she meets her supervisor who instructs her to leave whilst grabbing some of his personal affects. Some of them agree that it would be beneficial to inform friends and relatives what has happened [emphasis added] and stop to make phone calls. They are still present at the second impact."*
>
> [Experiences 623-680]

Table 13: **Number of calls that were with people INSIDE or OUTSIDE of the towers**

		Pre-evacuation	Evacuation
Survivors	**Outside of the towers**	22 [73%]	16 [53%]
	Inside of the towers	8 [27%]	7 [23%]
	Insufficient information	0 [0%]	2 [7%]
	Total	30	25
Fatalities	**Outside of the towers**	58 [76%]	11 [14%]
	Inside of the towers	8 [11%]	1 [1%]
	Insufficient information	10 [13%]	1 [1%]
	Total	76	13

Clearly this occupant delayed her evacuation in order to make a phone call(s). Although in this instance she survived she was making her way down the stairs when WTC2 collapsed.

Figure 19: **Physical location of telephone protagonists**



Pre-evacuation: Survivors Evacuation: Survivors

Furthermore, 75% of the outgoing phone calls (18/24) were to relatives (see Table 14 and Figure 20). Thus the majority of phone calls made by survivors during *pre-evacuation* were not to emergency personnel or colleagues within the building but to relatives. The database also provides some indication as to the nature of these calls.

Table 14: **Recipients of telephone calls made from tower occupants**

		Relative	Friend	Colleague	911	Elevator	Total
Survivors	**Pre-evacuation**	18 [75%]	4 [17%]	1 [4%]	1 [4%]	0 [0%]	24
	Evacuation	10 [53%]	3 [16%]	1 [5%]	1 [5%]	4 [21%]	19
Fatalities	**Pre-evacuation**	44 [81%]	2 [4%]	2 [4%]	5 [9%]	1 [2%]	54
	Evacuation	10 [91%]	0 [0%]	1 [9%]	0 [0%]	0 [0%]	11

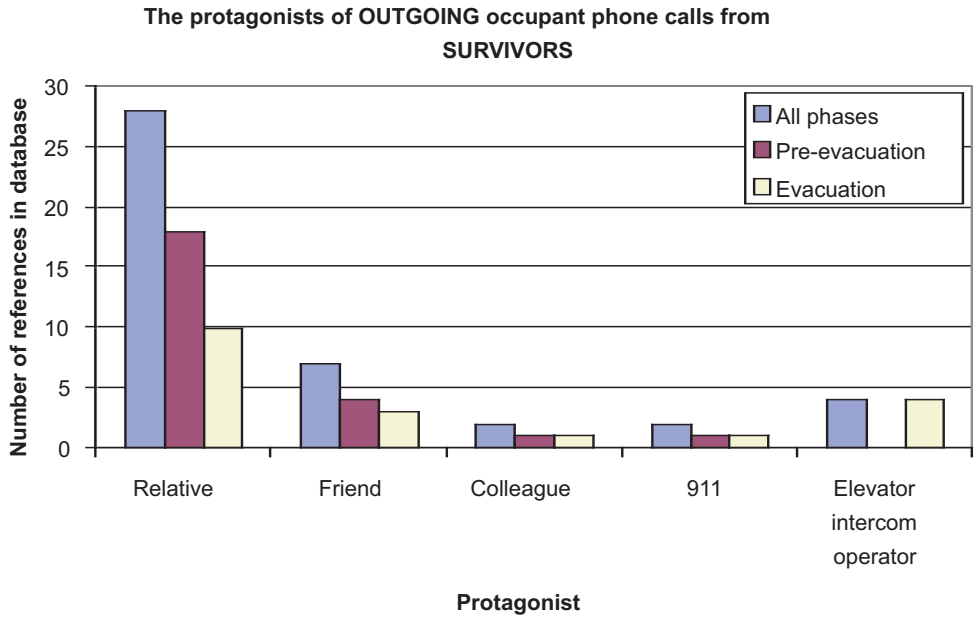
The data suggests that in these phone calls occupants would typically discuss the unfolding events with family commonly telling them what had happened and what their intentions were, for example:

> *"I called my nanny at home and told her to page my wife, tell her that a bomb went off, I was ok, and on my way out. My wife had taken our 9 month old for his check up.*
>
> [Experience 79]

In other instances occupants supplied information about the event and at the same time requested additional information, for example:

> *"I hung up with them and proceeded to call my wife and tell her I think some kind of bomb went off. She said she would check the TV and get back to me. By this time it was approximately 08:55."*
>
> [Experience 1093]

Figure 20: **Protagonists in telephone conversations MADE by SURIVING occupants**

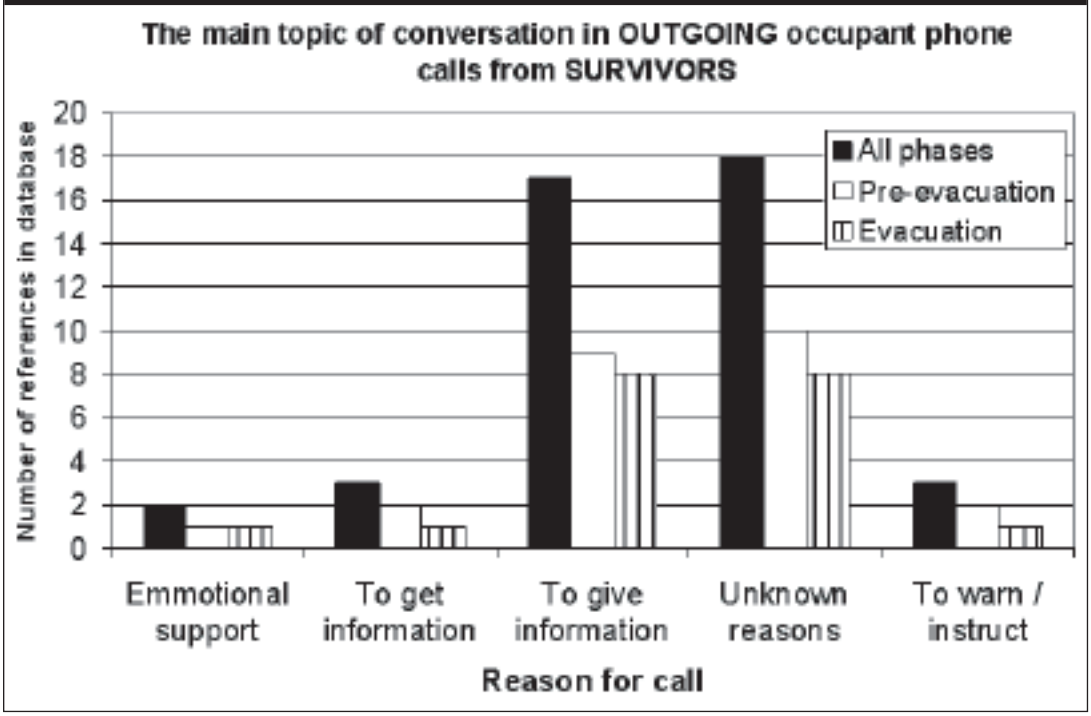


The main reason for making the phone calls cited by survivors (see Table 15 and Figure 21) was to provide information to family members (9/24 or 38% of calls). Calling to provide purely emotional support, to gain information and or to warn or instruct other people of danger were found with only minor frequency. However, it should be noted that most conversations would involve some element of emotional support and an exchange of information of various types. Conversations in which callers stated that they loved someone but mainly discussed the event itself and what they were going to do next would have been classed as *Giving Information.*

Table 15: **The main purpose of out-going (i.e. MADE CALL category) telephone conversations during pre-evacuation and evacuation**

		Emotional support	To get information	To give information	Unknown reasons	warn/ instruct	Total
Survivors	**Pre-evacuation**	1 [4%]	2 [8%]	9 [38%]	10 [42%]	2 [8%]	24
	Evacuation	1 [5%]	1 [5%]	8 [42%]	8 [42%]	1 [5%]	19
Fatalities	**Pre-evacuation**	1 [2%]	2 [4%]	34 [63%]	17 [31%]	0 [0%]	54
	Evacuation	0 [0%]	0 [0%]	5 [45%]	6 [55%]	0 [0%]	11

Figure 21: **Main topic of conversation from OUTGOING telephone calls made by SURVIVORS**



The propensity of occupants to make telephone calls is considered important as it is an action that slows occupant evacuation, especially as the majority of calls involved providing rather than receiving information.

6.7.1 Means by which phone calls were made

This section follows the previous analysis but investigates the method by which the telephone calls were made, i.e. land line or cell phone. In most instances insufficient detail was provided to make a judgement. The method of call could not be determined for 18/30 (60%) of survivors and 31/76 (41%) of fatalities during pre-evacuation.

For occupants involved in evacuating it was possible in some instances to deduce that they most likely were using cell phones. For example, occupants who stated that they were moving on the stairs and made a phone call must have used a cell phone. Examining the method used for telephone calls during the evacuation phase suggests that 13/25 (52%) of survivor calls were made from cell phones and that 9/25 (36%) were made from landlines.

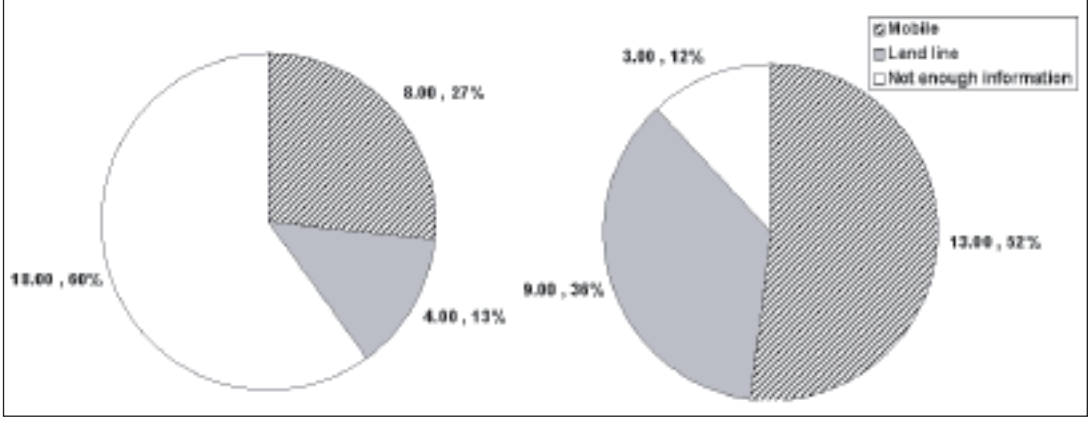
Table 16: **Number of calls that were made on mobiles or landlines**

		Pre-evacuation	Evacuation
Survivors	**Mobile**	8 [27%]	13 [52%]
	Land line	4 [13%]	9 [36%]
	Not enough information	18 [60%]	3 [12%]
	Total	30	25
Fatalities	**Mobile**	22 [29%]	8 [62%]
	Land line	23 [30%]	1 [8%]
	Not enough information	31 [41%]	4 [31%]
	Total	76	13

Mike McQuaid was on the stairs in WTC1 but at the 52nd floor left the stairs to make two calls he stated that:

> *"At 52, my partner and I went into some empty offices and called their loved ones, and the company we worked for."*
>
> [Experience 1334-1337]

Figure 22: **Type of telephone used in communication**



Pre-evacuation: Survivors

Evacuation: Survivors

During their evacuation, between 9:40 am and 9:45 am Brian Clark and a colleague stopped at the 31st floor, left the stairs and entered a conference room to make phone calls. He stated that:

> *"We got into their conference room, and each grabbed a phone. . I [Brian Clark] called my wife to tell her here's where I am. . I hadn't talked to her since about five to nine, I suppose, and this was about 20 to 10. Stanley talked to his wife"*
> [Experience 398-399,499,516]

He then proceeded to call 911. His companion during descent (Stanley) called his wife also. The remaining 4 phone calls cited in the database were made over elevator intercoms to operators.

6.8 USE OF EMAIL DURING THE EMERGENCY

This section examines the nature of email conversations during the emergency itself. The database was queried for instances of email communications. This revealed 7 occupants that reported email conversations post WTC1 impact. All were from occupants located in WTC1. Given the small number of people involved each instance is discussed in detail.

Four of the emails were made from fixed computer terminals. Three of the occupants were located on the 106th floor and died in the disaster. One was from a survivor who was located on the 89th floor, just below the impact zone.

The first account stated that at 9:05 am the occupant received an email from a colleague asking *"Pete, if you get this please let me know that you're okay."* [Experience 779]. He responded and continued a discussion that involved several emails. It could not be determined whether his colleague was in the same building or elsewhere. He was however trapped and it appears that the nature of the conversations was to determine his status. His final email at 9:16 am was to say that *"We are stuck"*.

The second account was from an occupant also located on the 106th floor of WTC1. He sent and email to his manager to ask *"Any idea which floor/side the plane crashed?"* [Experience 750]. The manager was most likely inside the same building. The nature of the conversation was to gain information about the event.

The fourth account concerns an occupant who received an email from a friend. The friend wrote at 9:05 am and said *"Check out the news. A plane just hit the World Trade Center."* [Experience 658]. The account implied that this was the first of many emails between them. It is not clear whether the friend was a colleague possibly inside the building or a friend elsewhere. The nature of the conversation was to ascertain their status and gain information

The final email from fixed computer terminals was from an occupant located on the 89th floor. He initially sought refuge from smoke and fire and sent the emails from this location. He was later led from the refuge by a fire marshal. The nature of the email conversations was unknown.

Three survivors sent/received emails using mobile technology (Blackberry 2 hand held email devices) during the descent. They passed the devices around to others during the descent. They emailed relatives and received emails describing what was going on around them.

6.9 COLLECTION OF ITEMS PRIOR TO EVACUATION

Just as making phone calls has the potential to slow occupant evacuation so too does the collection of personal belongings. Section 6.4 demonstrated that collecting items (i.e. preparing for evacuation) was one of the last actions undertaken by occupants prior to evacuating. This section provides some information into the types of items retrieved by occupants prior to evacuating.

Collecting belongings/items accounted for 29/268 (11%) of actions reported during pre-movement. These 29 actions originated from 25/94 (26.5%) of the surviving population. Only four occupants collected items twice. This does not mean only four occupants collected more than one item, but that four occupants actually interrupted an action in order to retrieve items on two separate occasions. The collect item category was used to indicate the collection of one or more items as a distinct action.

The data indicates that occupants mainly collected personal items. **Indeed personal items accounted for 79% of reported item collection actions. Work items represented only 17% of reported item collection actions.**

Table 17: **Frequency of item action types that were collected during PRE-EVACUATION by SURVIVORS**

	Personal item(s)	Work item(s)	Unknown	Total
Both towers	23 [79%]	5 [17%]	1 [3%]	29

Note: some occupants collect more than one item during an action
[ ] indicates percentage

The types of personal items that were collected ranged from coffee cups, sneakers, laptops, pocket books, bags, briefcases, wallet, purse, keys, phones, hats and shoes. The frequency of different types of personal items is shown in Table 18.

Table 18: **Summary of types of items that were collected**

Lap Top	Wallet	Keys	Bag	Phone	Clothing
14	6	1	18	2	3

Note: some occupants collect more than one item during an action

Most occupants that reported collecting items described collecting items from their desk whilst at their desk or within the immediate local vicinity. However, six instances of collect item experiences generated by six separate people explicitly stated that they had to return to their desk or office from a distant location. **The six people that reported this behaviour represented some 6/94 (6.4%) of the surviving population that stated actions during their pre-evacuation and 6/25 (24%) of the people that reported collecting items.**

Four accounts involved occupants being in another part of the office but then moving back to their desk to collect belongings [Experiences 24,150,157 and 3308]. Two of these were from the 93rd and 100th floors of WTC2 and one was from the 83rd and 67th floors of WTC1. Most of these reported collecting keys, bags and/or wallets. One occupant collected what he described as *"essential items"* (keys and bag) but left his laptop and $1,800 in cash he had withdrawn from the bank earlier in the day.

Two more extreme instances of occupants returning to their offices from some distance away were also found. Both of these came from WTC2 and occurred prior to the T2 impact. This first report was from an occupant that was just beginning their evacuation and was waiting in congestion on the stairs on the 100th floor of WTC2 [Experience 793]. The second and more extreme were from a couple of colleagues that were eating breakfast at the 44th floor sky lobby. They described travelling 34 floors upwards in a lift to collect one of their wallets:

> *"But Ramsundar had left his wallet at his desk and was afraid that if they left the building without it, he wouldn't be able to get back in to retrieve it. They found their 80th floor offices deserted except for two security guards."*
>
> [Experience 2159]

Collecting personal belongings/items clearly took place during the evacuation. Whilst in some instances this action can be accomplished quickly in other instances the action can take considerable time and involve significant additional travel – perhaps in the opposite direction to evacuation. As such the occurrence of this behaviour should be viewed as serious and potentially hazardous.

6.10 BEHAVIOURS ASSOCIATED WITH THE SEEK INFORMATION ACTION

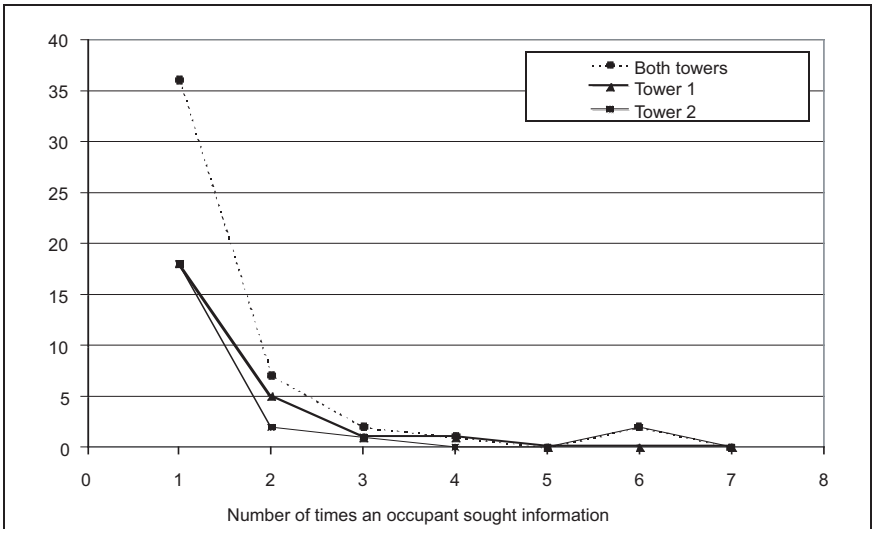
The *seek information* action was redefined as an action in which an occupant began to physically seek information. Using this definition, the *seek information* action represented 72/268 (27%) of actions reported during the pre-evacuation phase. As discussed previously this represented a sizable portion of reported pre-evacuation actions. These 72 seek information actions were generated by 48 different occupants (25 from WTC1 and 23 from WTC2). Thus, 51% (48/94) of the surviving occupants that stated that they had undertaken pre-evacuation actions undertook a *seek information* action as part of their pre-evacuation.

Table 19: **Frequency distribution data of the number of times that SURVIVING occupants sought information during PRE-EVACUATION**

Number of times an occupant sought information	Both towers	WTC1	WTC2
1	36 [75%]	18 [72%]	18 [78%]
2	7 [15%]	5 [20%]	2 [9%]
3	2 [4%]	1 [4%]	1 [4%]
4	1 [2%]	1 [4%]	0 [0%]
5	0 [0%]	0 [0%]	0 [0%]
6	2 [4%]	0 [0%]	2 [9%]

Examining the frequency of the *seek information* action we find that 75% of occupants sought information only once (see Table 19 and Figure 23) and that approximately 15% of occupants reported seeking information on two separate occasions. Of those occupants that reported seeking information, 28% of occupants in WTC1 reported seeking information more than once compared with 22% of occupants in WTC2.

Figure 23: **Frequency distribution of the number of times that a SURVIVING occupant sought information during PRE-EVACUATION**



Within the database for each general experience category there is a more specific category. For the *seek information* category, this is made up of the following sub-actions:

Seek information

a) Look out of window,
b) Listen to radio reports,
c) Watch television reports,
d) Check adjacent areas,
e) Check conditions in stairs, or
f) Go to find colleagues.

Using these sub-categories the database suggests that by far the most common behaviour when seeking information involved occupants looking out of windows. Indeed this sub-category accounted for 54% (19/35) of reported seek information actions in WTC1 and 74% (26/37) of reported seek information actions in WTC2 (see Table 20 and Figure 24). It is not surprising to note that more occupants in WTC2 looked out of the windows than in WTC1 as WTC1 was the first building hit. This may have enhanced their knowledge regarding the severity of the event and may account for the shorter pre-evacuation times found in WTC2 (see Section 6.1).

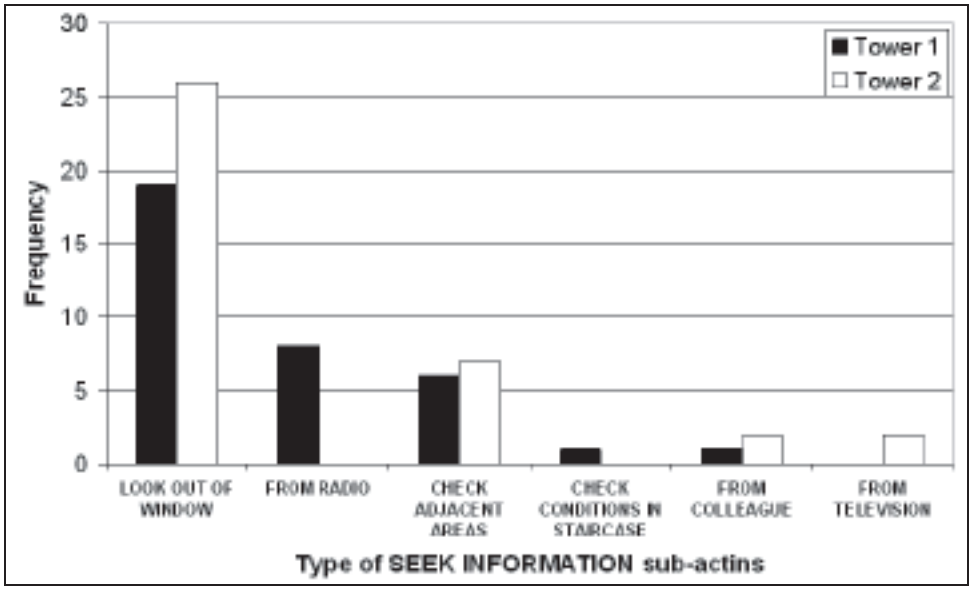
Table 20: **Constituent behaviours that comprised the SEEK INFORMATION category from SURVIVORS PRE-EVACUATION**

WTC1		WTC2	
Type of SEEK INFORMATION action	**#**	**Type of SEEK INFORMATION action**	**#**
LOOK OUT OF WINDOW	19 [54.3%]	LOOK OUT OF WINDOW	26 [74.3%]
FROM RADIO	8 [22.9%]	CHECK ADJACENT AREAS	7 [20%]
CHECK ADJACENT AREAS	6 [17.1%]	FROM COLLEAGUE	2 [5.7%]
CHECK CONDITIONS IN STAIRCASE	1 [2.9%]	FROM TELEVISION	2 [5.7%]
FROM COLLEAGUE	1 [2.9%]		
Total	35	**Total**	37

[ ] percentages in brackets

It is also interesting to note that televisions and radios served as a means of gaining information for 14% (10/72) of reported *seek information* actions. Some occupants described moving to check adjacent areas, i.e. corridors, rooms or the stairs. Within the database moving to check areas accounted for 21% (15/72) of the *seek information* actions. However, the need for occupants to look out of windows, listen to the radio, watch television or find colleagues (generally to ask what to do), accounts for 79% (58/72) of the reported *seek information* actions.

Figure 24: **Comparative frequencies of behaviours that comprised SEEK INFORMATION for both towers**



In the absence of good quality information from building security, the *seek information* action must be considered a rational precursor to any decision to evacuate. The *seek information* category is considered significant as, **these behaviours might have been eliminated if occupants had been provided with sufficient good quality information early during the evacuation. Providing occupants with sufficient information so as to limit the need for personal information gathering should be considered an essential part of any evacuation plan. Measures should be taken to ensure that the building information system is sufficiently hardened so as to survive plausible assaults. In addition, suitable back-up communications systems should be provided for fire wardens. This should ensure that the fire warden is capable of receiving situation information and is able to communicate to people under their care**.

6.11 OCCUPANT PERCEPTION OF THE EVENT

This section describes the occupants' perception of the event as it was unfolding. The database not only contains actions but any and all experiences listed in occupant reports. A relatively frequently cited experience was occupants' perception or their assessment of the disaster, for example:

> *"My first thought was that there had been an earthquake, then I thought it might be a bomb, however the thought of a terrorist never crossed my mind."*
>
> [Experience 3402]

Whilst another example from the 79th floor of WTC2 during pre-evacuation stated that:

> *"I heard "a plane crashed" and I believed it. I believed it was an accident, one of those little planes that take off at rinky dink airports. Not a 727 or 747 or the like."*
>
> [Experience 684]

A final example was from an occupant in WTC2 in the midst of their evacuation somewhere between the 65th and 70th floor at the point of T2 impact that stated:

> *"Oh my god, they bombed our building now!"*
>
> [Experience 315]

The database was interrogated for references of occupants' assessment of the event *during pre-evacuation*. In total this revealed 98 accounts of occupants making an assessment of the event. These 98 assessments were from 91 occupants (this includes both survivors and fatalities). An attempt was made at determining whether occupants perceived the events as serious. Unfortunately, the database contains little information concerning this issue and so this analysis revealed little of any significance. Consequently an approach was taken that focused on what people thought had caused the disturbance. The overall *assessment of event* category was subdivide into the following 9 sub-categories:

Aircraft impact	The occupant stated that they thought that an aircraft had impacted the building.
Aircraft impact (Terrorism)	The occupant stated that they thought that an aircraft had impacted the building and that it was an act of terrorism.
Bomb	The occupant stated that they thought it was a bomb that had exploded somewhere in the building.
Did not know	The occupant reported that they had no idea what had caused the disturbance.
Did not think it was aircraft	This category represents occupants who stated that they did not think an aircraft had caused the disturbance.
Earthquake	The occupant stated that they thought that the building disruption was the result of an earthquake.
Explosion (Unknown source)	The occupant stated that they thought that an explosion had occurred somewhere but also stated that they did not have any idea what it may have been.
Unintentional explosion	The occupant stated that they thought that an explosion had occurred somewhere but also stated that they did not think that it was intentional.
Routine noise	This category was used when an occupant specified that they thought that the disturbance was caused by routine noises.

Table 21 shows the frequency of each of the assessment sub-categories cited by occupants during pre-evacuation. The most frequently reported assessment was that the incident was the result of an *aircraft impact* (53% (52/98) of all accounts). Indeed this is true for both survivors and fatalities from either WTC tower. Some 19% (19/98) believed that the incident was the result of a terror attack, either by an aircraft or bomb, while some 17% (17/98) of occupants did not know what had caused the disturbance. If we compare this by building, this suggests that 32% (10/32) of the people in WTC2 for which we have data, believed that the incident was a result of a terror attack, either by an aircraft or bomb, while only 13% (9/67) of the occupants in WTC1 believed that they were subjected to a terrorist attack. This belief may have contributed to the rapid response times recorded in WTC2 in comparison to WTC1.

Table 21: **Summary of occupant assessment of the event**

	WTC1		WTC2	
Assessment of event	**Survivors**	**Fatalities**	**Survivors**	**Fatalities**
Aircraft impact	16 [33%]	10 [56%]	7 [25%]	1 [33%]
Aircraft impact (terrorism)	4 [8%]	0 [0%]	3 [11%]	1 [33%]
Bomb	3 [6%]	2 [11%]	5 [18%]	1 [33%]
Did not know	8 [16%]	4 [22%]	5 [18%]	0 [0%]
Did not think it was plane	1 [2%]	0 [0%]	0 [0%]	0 [0%]
Earthquake	3 [6%]	1 [6%]	1 [4%]	0 [0%]
Explosion (unknown)	6 [12%]	1 [6%]	4 [14%]	0 [0%]
Other (see notes)	5 [10%]	0 [0%]	0 [0%]	0 [0%]
Routine noise	0 [0%]	0 [0%]	3 [11%]	0 [0%]
Unintentional explosion	3 [6%]	0 [0%]	0 [0%]	0 [0%]
Total	49	18	28	3
Thought it was something else	29 [59%]	8 [44%]	18 [64%]	1 [33%]
Thought it was an aircraft impact	20 [41%]	10 [56%]	10 [36%]	2 [67%]

It is useful to group the categories into those that indicated that they thought the incident was the result of an aircraft impact and those that did not. This categorisation is shown below:

1 Thought it was aircraft
- a) aircraft impact
- b) aircraft impact (Terrorism)

2 Did not think it was an aircraft
- a) Bomb
- b) Did not know
- c) Did not think it was aircraft
- d) Earthquake
- e) Explosion (Unknown source)
- f) Unintentional explosion
- g) Routine noise

Using these categories we find that during their pre-evacuation phase some 41% (20/49) of survivors in WTC1 reported that they thought the incident was the result of an aircraft impact. Similarly, 36% (10/28) of the survivors in WTC2 believed that the incident was the result of an aircraft impact. Thus in both towers, while a large number of people suspected that the incident was aircraft related, the majority of the survivors *did not* believe that the assault was the result of an aircraft impact. This suggests that all survivors did not have accurate information regarding the event.

It was also possible to interrogate the locations of occupants and relate this to their assessment of the event. Given the limited number of data points available for analysis, the location of occupants has been categorised into the following four distinct zones and depicted in Figure 25.

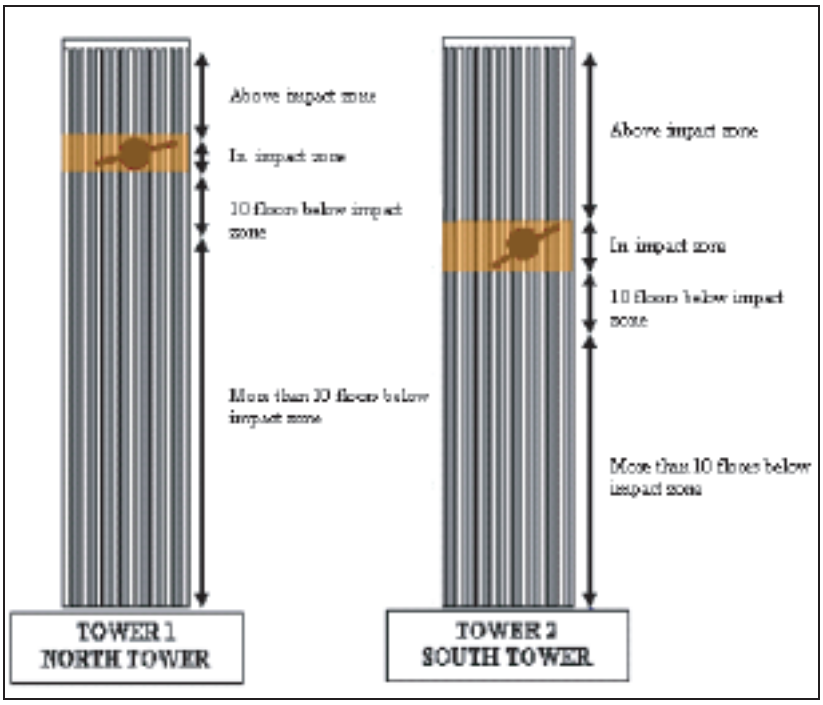
Above impact Above the impact zone of the tower, i.e. above 98th floor in WTC1 and above the 84th floor in WTC2.

In impact zone Between the 94th and 98th floors in WTC1 and between the 78th and 84th floors in WTC2.

<10 below impact zone Between the 83th and 94rd floors in WTC1 and between the 67th and 78th floors in WTC2.

>10 below impact Floors lower than the 84th in WTC1 and below the 68th in WTC2.

Figure 25: **Zones used in the analysis of event awareness**



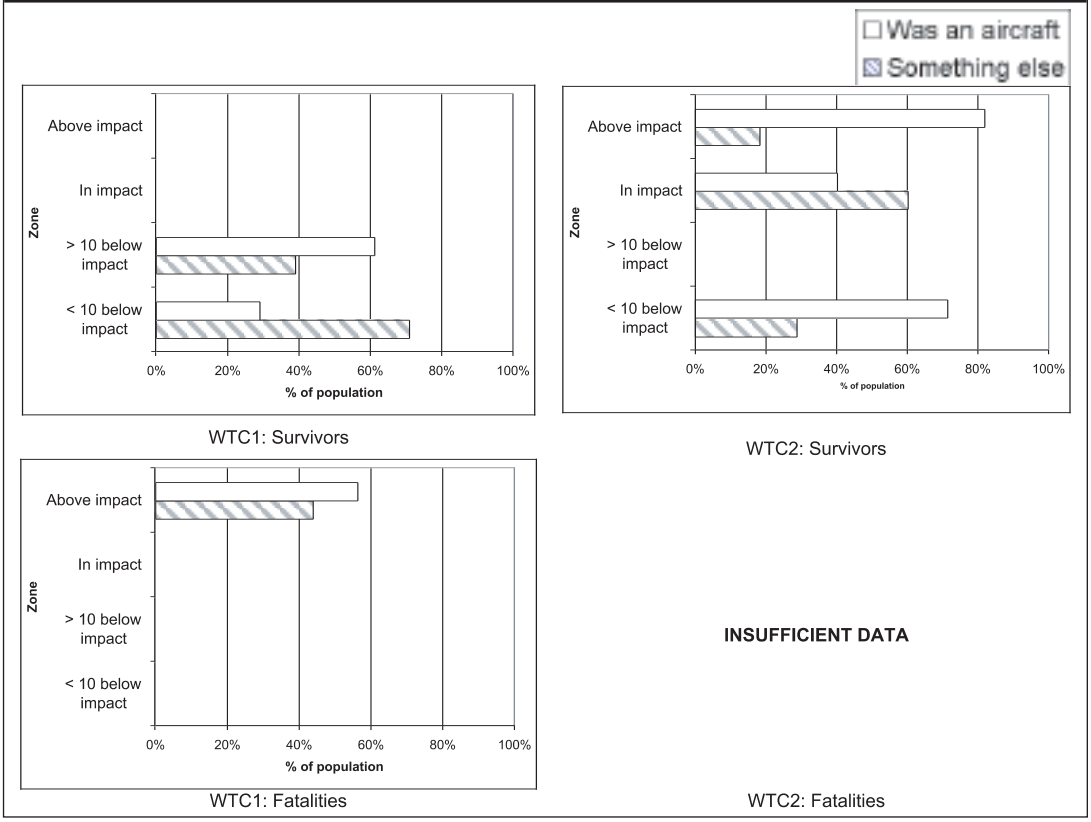
Based on this scheme the following data was extracted from the database (see Table 22 and Figure 26). A significant majority 22/29 (71%) of occupants from WTC1 situated more than 10 floors below the impact zone thought the impact was caused by something other than an aircraft. In contrast a majority 11/18 (61.1%) of surviving occupants 10 floors below the impact zone suspected that the incident was the result of an aircraft impact.

Table 22: **Assessment of event by location relative to impact zone**

	Assessment of event	<10 below impact	>10 below impact	In impact	Above impact	Total
WTC1: Survivors	**Something else**	22 [71%]	7 [38.9%]	0 [0%]	0 [0%]	29
	Aircraft	9 [29%]	11 [61.1%]	0 [0%]	0 [0%]	20
WTC1: Fatalities	**Something else**	0 [0%]	1 [0%]	0 [0%]	7 [43.8%]	8
	Aircraft	1 [0%]	0 [0%]	0 [0%]	9 [56.3%]	10
WTC2: Survivors	**Something else**	2 [28.6%]	0 [0%]	6 [60%]	2 [18.2%]	10
	Aircraft	5 [71.4%]	0 [0%]	4 [40%]	9 [81.8%]	18
WTC2: Survivors	**Something else**	0 [0%]	0 [0%]	1 [33%]]	0 [0%]	1
	Aircraft	0 [0%]	0 [0%]	0 [0%]	2 [67%]	2

This suggests that knowledge of the event was linked to proximity to the disaster in some way. In WTC2 many occupants had access to windows and would have been able to see the unfolding events in WTC1. As a result, survivors from most locations within WTC2 suspected that the incidents were aircraft related.

Figure 26: **Percentage of population in each zone that either thought it was an aircraft or thought it was something else**



6.12 RELUCTANCE TO BREAK WINDOWS

From a number of accounts from fatalities it was noted that occupants described being unsure whether they should break windows. This confusion generally arose from trapped occupants that were seeking shelter in the WTC towers. Some of these occupants reported an initial reluctance to break the windows, presumably recognising the threat to those on the ground below. However as the fire developed and the conditions in their vicinity progressively worsened, most of the occupants that were initially reluctant decided that their survival depended upon gaining access to fresh air and thus decided to break windows.

7. Data analysis: Evacuation

The previous section of the report focused on pre-evacuation issues, here we focus on the actual evacuation phase. Recall that in this work evacuation is defined as starting once an occupant begins to take decisive action that results in the occupant leaving the floor from which they started. Movement from one room to another room on the same floor to seek shelter and wait for rescue was grouped into the pre-evacuation phase. Essentially, we are considering the descent phase of the evacuation.

7.1 OCCUPANT ASSESSMENT OF CONGESTION AND TRAVEL SPEED ON DESCENT

In their accounts of the evacuation, a number of occupants provided a description of both congestion and travel conditions on the stairs and sky lobbies. Here we review the occupants assessment of these conditions. Within the database experiences were recorded when occupants described the flow conditions and/or level of congestion, for example an occupant from WTC2 who was descending the stairs somewhere between the 44th and 32nd floor stated that:

> *"We went down again. Nobody on the stairway at all. Easy travel, just the two of us."*
>
> [Experience 496]

Another example, this time from an unknown location on the stairs in WTC1 stated that:

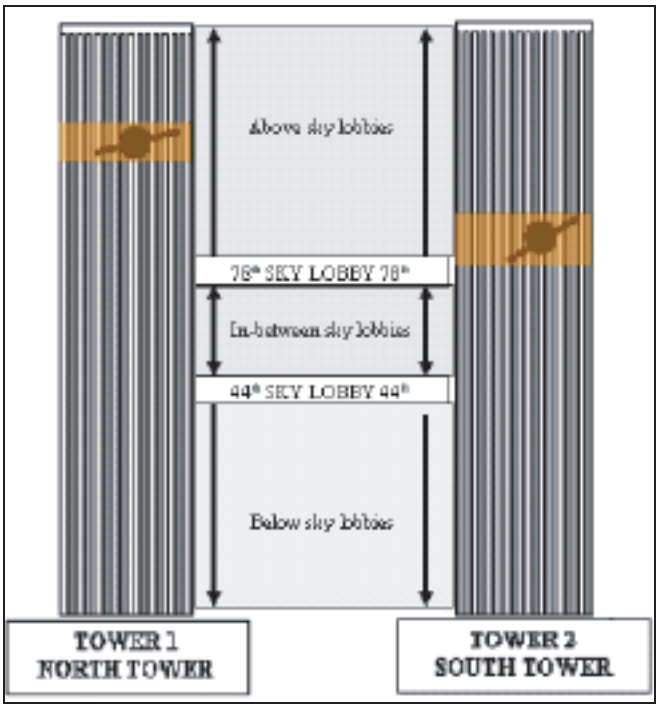
> *"Now they were moving incredibly slowly, step by step."*
>
> [Experience 2438]

Using actual occupant assessments it is possible to form a picture of the flow conditions within the building as gauged by the occupants themselves. To facilitate this analysis, it was necessary to divide the building into five distinct regions (see Figure 27);

1. The area above the 78th floor sky lobby.
2. The area below the 44th sky lobby.
3. The area between the 78th and 44th floor sky lobbies.
4. On the floor of the 78th sky lobby.
5. On the floor of the 44th sky lobby.

Using these regions the database was interrogated to find occupant descriptions of the flow rates and level of congestion within each of these zones. A more detailed analysis in which each individual staircase was considered and/or specific blocks of the stairs was not possible as in most cases, occupants did not state which stair they used. Furthermore, some occupant reports that described using specific stairs later gave contradicting statements that invalidated their claims. In addition some difficulties arose in determining occupants' exact location within the building, hence the rather broad categorisation in Figure 27.

Figure 27: **Areas considered in this assessment**



7.1.1 Congestion at sky lobbies

Only a handful of reports described conditions at the sky lobbies (8 in total) and these provided little information (see Table 23). The only finding considered significant is that all of the accounts at the 78th sky lobby of WTC2 described "lots of people". For example, one occupant stated that:

> *"By now, 60 to 100 people had gathered at the 78th-floor sky lobby"*
>
> [Experience 1077]

Whilst another occupant again at the 78th sky lobby in WTC2 stated that:

> *"But he looked into the marble-lined lobby, more than half a city block long, and saw people were standing shoulder to shoulder, waiting for elevators. This is pointless, he thought."*
>
> [Experience 2182]

These quotations from WTC2 were made prior to that building being hit. It is not clear why these people were gathering in the sky lobby. Most likely they were awaiting the express elevators, but some of those in WTC2 could have been resting and assessing their situation, trying to decide whether or not to continue to evacuate the building or return to their desks as suggested by the next quotation:

> *"I asked Carol, "What do you think about that announcement? Do you think we should stay here and see what happens?" She replied, "I think we need some fresh air." I responded, "I think you're right – I need some fresh air too. I'm with you. We're out of here."*
>
> [Experience 205]

Another occupant who was using an elevator to evacuate, stated that:

> *"As she approached the 78th floor, where the sky lobby is "something made me stop on 78. I don't know what it was. I thought, at 78 maybe, we would get some information. There was the communication desk there. I got out, other people got out."*
>
> [Experience 725]

These accounts are indicative of others that suggest that the 78th floor sky lobby was used as a staging point where occupants decided what to do, while some transferred to elevators to exit the building. As the impact to WTC2 was between the 78th and 84th floors this proved to be a very dangerous place to congregate and reassess evacuation options.

Table 23: **Perceived conditions in 78th floor Sky Lobby**

	WTC1		WTC2	
Location	**Description**	**#**	**Description**	**#**
78th Sky Lobby	LOTS OF PEOPLE	1	LOTS OF PEOPLE	6
	NOT MANY PEOPLE	1	NOT MANY PEOPLE	0

7.1.2 Perception of stair flow rates for WTC1

Examining the stair flow rate for WTC1 (see Table 24) suggests that the flow was relatively uncongested on the upper floors (with 5 reports of "not many people") whilst for similar time durations the stairs were described as being full of occupants (with 4 reports of "lots of people"). If it is assumed that these statements do not contradict each other then we can conclude that either the conditions on the stairs changed rapidly over time or that the occupants were describing different stairs or locations on the same stairs. There is some evidence to support the view that the reports of 'not many people' on the stairs may have originated predominately from the later part of the evacuation, while the 'lots of people' observation may have originated from the earlier part of the evacuation. Unfortunately, due to the amount of data and the nature of the data, it is not possible to clarify the situation.

Between the 78th and 44th sky lobbies occupants described the flow as being slow (4 reports), orderly (3 reports), with people sat on the stairs (3 reports) and their being lots of people (2 reports). The general conclusion from these reports is that the stairs were more packed than those above the 78th floor lobby. The flow may be categorised as slow but orderly. Unfortunately, there is insufficient information to determine when the majority of these observations were made.

Below the 44th floor sky lobby the data is more consistent with occupants describing the flow as slow (9 reports), there being lots of people (8 reports) while being orderly (4 reports). The number of reports may suggest that the flow in this area of the building was slower than other areas. Furthermore the flow could be categorised as being slow, heavily congested and orderly.

Table 24: **Perception of conditions on the stairs as a function of response times (R: rapid, M: moderate, L: long)**

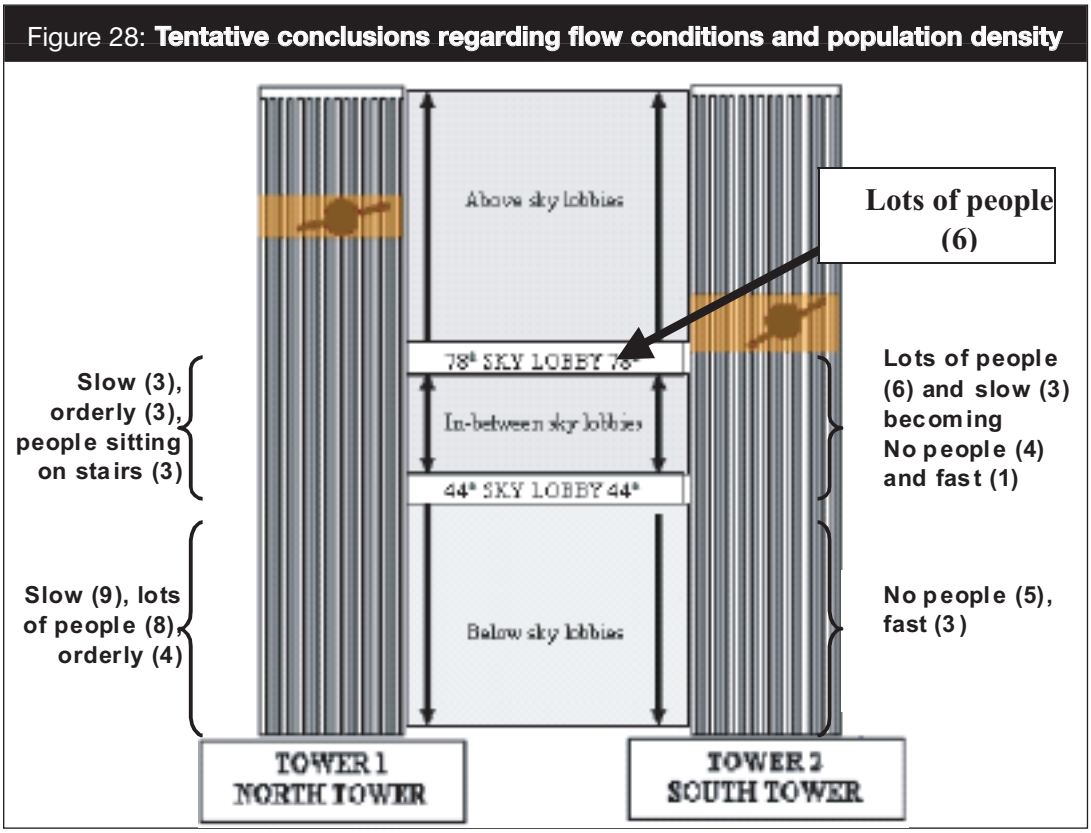
		WTC1				WTC2				
Location	**Description**	**R**	**M**	**L**	**ALL**	**Description**	**R**	**M**	**L**	**ALL**
Above the 78th Sky lobby	No people	0	0	0	1	No people	0	1	0	1
	Not many people	0	1	3	5	Not many people	2	1	0	3
	Little crowded	0	0	0	0	Little crowded	1	0	0	1
	Lots of people	1	1	1	4	Lots of people	1	1	0	2
	Moved slow	0	0	0	1	Moved slow	0	0	0	0
	Moved fast	0	1	0	2	Moved fast	1	0	0	1
	People sitting on stairs	0	0	0	0	People sitting on stairs	0	0	0	0
	Met passable blockage	0	0	0	1	Met passable blockage	0	1	0	3
	Orderly	2	0	0	3	Orderly	1	1	0	2
Between the 78th and 44th sky lobbies	No people	0	0	0	0	No people	0	2	0	4
	Not many people	0	1	0	1	Not many people	0	0	1	1
	Little crowded	0	0	0	0	Little crowded	0	0	0	0
	Lots of people	1	0	0	2	Lots of people	5	0	1	6
	Moved slow	1	0	0	4	Moved slow	2	0	1	3
	Moved fast	1	0	0	2	Moved fast	0	0	1	2
	People sitting on stairs	1	0	0	3	People sitting on stairs		0	0	0
	Met passable blockage	0	0	0	0	Met passable blockage	1	0	1	1
	Orderly	1	1	0	3	Orderly	3	0	0	3
Below the 44th sky lobby	No people	0	0	0	1	No people	0	2	1	5
	Not many people	1	0	0	2	Not many people	0	0	0	2
	Little crowded	1	0	0	1	Little crowded	0	0	0	0
	Lots of people	3	0	0	8	Lots of people	0	0	0	2
	Moved slow	2	1	0	9	Moved slow	0	0	0	0
	Moved fast	0	0	0	1	Moved fast	2	0	0	3
	People sitting on stairs	0	1	0	1	People sitting on stairs	0	0	0	0
	Met passable blockage	0	0	0	0	Met passable blockage	0	0	0	0
	Orderly	2	0	0	4	Orderly	0	0	0	1

7.1.3 Perception of stair flow rates for WTC2

The most common reports of flow conditions on the stairs in WTC2 above the 78th floor sky lobby (see Table 24) were that there were not many people (3 reports), that some kind of blockage was met (3 reports), that the flow was orderly (2 reports) and that their were lots of people (2 reports). The contradiction in this dataset may refer to a change in flow conditions throughout the evacuation and/or different flow conditions on different stairs. Once again, it is not possible to determine which staircase people used and at what time, hence the possible contradictions in the level of crowding.

Between the 78th and 44th floor sky lobbies reports of flow conditions were that there were lots of people (6 reports), no people (4 reports), that the flow was orderly (3 reports) and that the flow was slow (3 reports). Reports of crowding appear to have been made early in the evacuation while the reports of small numbers of people were made in the later part of the evacuation, possibly explaining this contradiction.

Figure 28: **Tentative conclusions regarding flow conditions and population density**



The examples of congestion that were reported suggested quite severe congestion, for example:

> *"Sometimes the line in the stairwell stopped cold. Congestion on the lower floors. We'd be standing in the stairwell, not moving forward, with voices above screaming, "No! Don't stop! Go down! Keep moving!""*
>
> [Experience 2588]

and,

> *"People were jam-packed on the 66th floor. Anthony was starting to get nervous."*
>
> [Experience 2640]

"Every so often the procession of people would come to a halt, which was not pleasant. I didn't know if it would ever start up again. Thankfully it always would, albeit a minute or two later."

[Experience 1128]

Reports from below the 44th sky lobby were that there were no people (5 reports) and that they 'moved fast' (3 reports). This data suggest as fast moving flow below the 44th floor.

To summarise, while data is scarce and in some cases contradictory, there are some tentative conclusions that may be drawn from the data. The data suggest that the stairs were packed and moving slowly below the 44th floor in WTC1 and slow between the 44th and 78th floors. In WTC2 the data suggests that there were lots of people at the sky lobby on the 78th floor. The stairs in WTC2 may have been initially packed and slow moving between the 78th and 44th sky lobbies but later may have become less packed. The stairs below the 44th sky lobby were not densely packed and fast moving. Most flows were described as orderly even those that were slow and heavily congested (see Figure 28).

7.2 OBSTRUCTIONS TO STAIRS

A number of occupants reported obstructions to the stairs in both towers that hindered the progress of their evacuation. In this section we examine the nature of these obstructions.

7.2.1 WTC1: The passage of injured occupants

Accounts in the database suggest that the passage of injured occupants down the stairs constricted the effective width available to the mobile occupants and caused the flow to stop in places. For example:

"We had to stop many times for the injured to pass by. Sometimes we would be stopped for at least 5 to 10 minutes. When an injured employee would come down the stairs, we would have to stop and get totally still and flat against the wall. At one point."

[Experience 3433]

While it may be reasonable to assume that occupants would consider this type of incident to be a serious event warranting mention, only two accounts actually describe the flow as totally stopped. More common was a restriction to the effective width of the stairs. For example, the uninjured occupants would form a single file using only one side of the stairs allowing the injured to pass by. For example an occupant described streams of people on the stairs but all on the right hand side, so as to leave the left side free for the injured and firefighters. This behaviour was corroborated by another occupant who stated that:

"Everybody was staying on the right-hand side of the stairs and letting people that were severely hurt go down on the other side."

[Experience 3173]

Unfortunately there is insufficient data within the database to quantitatively investigate this further. However, the data does highlight instances of evacuating injured occupants completely stopping the flow down the stairs and restricting the effective width on the stairs. This altruistic behaviour supports the view that the evacuation was calm and non-competitive in nature.

7.2.2 WTC1: The passage of firefighters

Another important factor that may have reduced the effective width on the stairs was the passage of firefighters making their way up the stairs. Indeed, some 9 accounts describe firefighters as presenting some sort of blockage to occupant evacuation on the stairs. One occupant described the flow of firefighters as, "non-stop coming up the stairs from the 38th floor onwards" (Mike McQuaid). Other accounts suggest that the passage of the firefighters up the stairs slowed their evacuation, for example, Dharam Pal stated that at the 24th floor he encountered firefighters coming up the stairs that slowed his downward flow. This was corroborated by others such as Jan Khan who stated that firemen served to tie up the flow in the stairs.

7.2.2.1 Reduction to the effective width of the stairs

Three accounts describe a reduction in the effective width, for example Peter Bitwinski stated that the firefighters asked them to move aside so that they could bring up equipment, which they did. Another occupant, Brian Stobbie, stated that at the 40th floor he was told to move to the right as firefighters were coming up the stairs. Other occupants described the reduction to the effective width as being continuous. For example, Juliette Bergman stated that there were streams of people on the stairs all on the right so as to leave the left free for the injured and firefighters."

7.2.2.2 Taking breaks

In addition resting firefighters may also have reduced the effective width of the stairs. For example, Genelle Guzman-McMillan stated that they saw "firefighters at the 40th floor resting and taking a break". This was corroborated by John Abruzzo who stated that, "firefighters were exhausted on the side of the stairwell trying to catch their breath."

7.2.2.3 Forcing occupants to wait

One report describes firefighters as completely stopping the flow for a period of time

> *"At the 12th floor we had to wait to let a large group of firefighters pass by.*
>
> [Experience 418]

To summarise, there a very few accounts within the database of the passage of firefighters up the stairs. However, the accounts that are available suggest that the firefighters may have hindered the passage of some occupants in WTC1. The available accounts describe firefighters as constricting the effective width whilst moving up the stairs and while recovering from fatigue. Several accounts describe the flow as coming to a complete halt. All of these reports were taken from floors below the 44th floor. These events may have contributed to the poor flow conditions in those areas of the building (see Section 7.1.2). It is suggested that as part of firefighter training, firefighters be instructed that during the ascent of tall buildings, prior to taking a rest period, they should move off the stairs, if considered safe, in order not to obstruct the flow of evacuating occupants.

7.2.3 WTC1: The presence of water on stairs

Another possible obstruction on the stairs that may have contributed to the slow progress was the presence of water on the stairs. Four reports describe water on the stairs with some describing the water as being ankle deep, *"After the 18th floor there was water in the stairs, ankle deep."* [Experience 3437]. Water was reported by occupants only below the 44th floor. The presence of water would have served to slow occupant evacuation as movement rates would have been severely hindered by the presence of water and some occupants may have even slipped and fell in the treacherous conditions. For example Clair McIntyre described conditions as having water dripping down the stairs and there being no lights. She also described twice slipping and falling on the wet stairs [Experiences 1288-1312].

The origin of the water is unknown although occupants did describe sprinklers as being operative. Another potential source of water may have been from the firefighters' attempts to extinguish fires.

7.2.4 WTC2: The passage of injured occupants

In WTC1 it was found that uninjured occupants tended to stand to the left during evacuation to let the injured past. This was cited by many occupants as a reason for the slow descent. Here we examine if similar conditions developed in WTC2.

Accounts describing delays resulting from the passage of injured occupants were scarcer in WTC2 than in WTC1. This may result from the injuries occurring some 20 minutes after T1 impact and the initiation of the WTC2 evacuation and the fact that many occupants used lifts instead of the stairs (see Section 7.3). Regardless of the causes, there were only five reports from occupants of the injured passing them on the stairs. Some accounts described occupants helping other injured occupants down the stairs, for example:

> *"The critically injured were passing us"*
>
> [Experience 3286].

> *"When we got below the thirtieth floor, they started to bring down injured people from flights above."*
>
> [Experience 2614]

Another account describes having to stop to let the injured past,

> *"We just keep going after that, not stopping until an injured man needs to pass us. When he passes us he turns around and says "how you doin'?" We realize that it's Keating Crown, a coworker injured when the plane hit the building. Blood covers him from head to toe."*
>
> [Experience 322]

Another account describes an evacuation regime in which occupants only used one side of the stairs.

> *"Firefighters were coming up on the inside, people were going down on the outside, and the injured people went down the middle."*
>
> [Experience 3129]

This single account describes a regime with three flows, the uninjured on the inside (left hand side), the injured in the centre, and firefighters on the outside lane (the right hand side).

Similarly to WTC1 this flow configuration would have reduced the effective width of the stairs and served to reduce the flow rate down the stairs. Also evident was an instance of the flow completely halting as a result of the evacuation of the injured. However, once again, there are very few accounts of this behaviour within the database.

7.2.5 WTC2: The passage of firefighters

Reports of firefighters in WTC2 were also scarcer than in WTC1 although firefighters were present as indicated by ***three*** occupant reports. This primarily results from significant numbers of firefighters entering the building only after the WTC2 impact and some 20 minutes after the evacuation started. As in WTC1 they were described as carrying equipment and moving slowly:

> *"It was somewhere in the 50s that they encountered the first firefighter, she said. They were moving in small packs, carrying a load of heavy equipment, which clearly slowed them down."*
>
> [Experience 762]

Another important similarity was that the ascending firefighters again narrowed the effective width of the stairs:

> *"Firefighters were coming up on the inside, people were going down on the outside, and the injured people went down the middle."*
>
> [Experience 3129]

This was corroborated by the only other report of firefighters on the stairs from WTC2:

> *"The exiting of the building slowed considerably at this point. People who had been burned and/or injured were being brought down and the firefighters were trying to get into different floors of the building to make sure everyone had been evacuated."*
>
> [Experience 3380]

While the reported frequency of firefighters in WTC2 is even smaller than that of WTC1, these reports are similar in nature. Namely that the effective width was narrowed and that on occasion occupants would have stopped to let firefighters pass by.

7.2.6 WTC2: Water on the stairs

Unlike WTC1 there were no reports of water on the stairs from WTC2.

7.3 USAGE OF ELEVATORS FOR EVACUATION

This section investigates the use of elevators by occupants as a means of evacuation. It should be noted that not all of the elevators within the towers were continuous, running the total height of the building – most elevators ran only a portion of the building. The elevator system in each tower comprised local lifts that served specific floors and some express elevators that ran between sky lobbies and from the Windows to the World restaurant and the main entrance lobby. Evacuating occupants from the upper floors would have had to gain access to the sky lobby in order to take a lift to the bottom of the tower.

Within the database there are no accounts describing the usage of elevators within WTC1. This is thought to be due to most lifts being disabled by the impact. However in WTC2 a significant amount of elevator use was described in occupant accounts. There are 95 occupant accounts reporting evacuation phase experiences in WTC2. Of these, 26 accounts (28.4%) of elevator evacuation usage are reported pre-T2 and represent some 38 elevator embarkations (see Table 25). Most of these accounts – 16/38 (42%) – took place at the 78th floor sky lobby and most – 11/16 (69%) – involved taking the elevator all the way to the ground level.

Table 25: **Summary of elevator usage in WTC2**

	Status of elevator users	**Number of embarkations**
78 to 0	10 survivors, 1 Fatality	11
78 to unknown location	Survivors	2
78 to 77	Survivors	1
86 to 78	Survivors	1
40 to 0	Survivors	3
93 to 78	Survivors	2
87 to unknown location	Survivors	2
91 to 78	Survivors	2
unknown location To 78	Fatalities	2
44 to 0	Survivors	2
95 to 0	Survivors	1
44 to 78	Survivors	2
78 to 80	Survivors	2
80 to 78	Survivors	1
60 to unknown location	Fatality	1
unknown lift use event	Survivors	3
Total embarkations		38
People involved		28
Number of fatalities		3
Number of survivors		25
Average number of floors travelled		46 floors
Number of elevator journeys upwards		2
Number of people that reported using more than one elevator		5
Number of embarkations at the 78th sky lobby		16

The average number of floors travelled by occupants using elevators was 46 floors. Two occupant accounts describe using elevators to travel upwards (from the 44th floor) to collect personal belongings on the 80th floor. This involved changing elevators at the 78th floor sky lobby. On their descent they only took the elevator from the 80th to the 78th floor. In total 5 occupants reported using an elevator more than once. All of these involved travelling to the 78th floor then changing to another elevator (2 to the bottom and 2 to the 80th floor; to collect belongings).

Given that the majority of elevator use occurred at the 78th floor sky lobby it is important to assess, in more detail, the occupant accounts at this location. These accounts suggest that the sky lobby was densely packed (see section 7.1.1) with people – most of whom were waiting for elevators for example, one occupant stated;

> *"… he looked into the marble-lined lobby, more than half a city block long, and saw people were standing shoulder to shoulder, waiting for elevators."*
>
> [Experience 2182].

Other accounts substantiate this description of congestion and substantial elevator queues. It was particularly unfortunate that the assault on WTC2 took place just above the 78th sky lobby, a staging point where numerous occupants were waiting for elevators and assessing their evacuation options.

The significant elevator use, in itself, indicates that occupants did not follow the recognised protocol for evacuation. There seemed to be some confusion as to whether using the elevators was a permissible evacuation strategy, for example an occupant is reported to have said:

> *"Shouldn't we be taking the stairs in an emergency like this?" which was replied by her colleague with, "No! Just get in the elevator! C'mon!"*
>
> [Experience 1172].

Another occupant stated that;

> *"it was okay to take an elevator as they still had power."*
>
> [Experience 1064].

The experience of some occupants of the 1993 incident made the elevators a much more attractive option then using the stairs.

> *"They joined the nervous, milling crowd filling the big elevator lobby, where a dozen room-size express elevators could make the trip to the ground floor in 60 seconds."*
>
> [Experience 2099]

Other occupants explicitly stated that they did not relish the thought of evacuating via the stairs;

> *"We got to the 78th floor and Judy said, "Let's see if the elevators are working. I'm thinking I shouldn't be taking an elevator, but I guess the thought of walking down 78th floors in my high heels was not exactly something I wanted to do."*
>
> [Experience 3314].

In addition some occupants were instructed to use elevators by emergency personnel at the 40th floor (Judy Wein, Gigi Singer and Ed Nicholls [Experiences 2108]). The net result of the elevator use was that the sky lobby was crowded and that the lifts themselves were crowded. For example, one occupant at the 78th floor stated that:

> *"[he] squeezed into an express elevator packed with 25 people evacuating the south tower."*
>
> [Experience 2030]

Further accounts described 25-30 people being in elevators and that;

> *".….elevators were all over capacity"*
>
> [Experience 2389].

Regardless of their reasons, significant elevator use occurred in WTC2.

Based on the reported usage of elevators in the database, it is not possible to conclude from this information alone that the elevators played a *significant positive role* in the evacuation success of WTC2. However, it is interesting to note that occupants in WTC2 reported low levels of congestion on stairs and relatively high rates of descent (see sections 7.1.2, 7.1.3 and 7.5). It would appear reasonable to assume that the heavy reported usage of elevators in WTC2 prior to T2 could have made two positive contributions to the evacuation. Firstly, heavy usage of elevators would have assisted clearing large numbers of people from the upper floors of WTC2 prior to the assault on that building. Secondly, the usage of elevators by significant numbers of people would have eased the congestion on the stairs in WTC2, making movement on the stairs more efficient.

7.4 GROUP BEHAVIOUR

Group behaviour is an important aspect of evacuation as groups have the potential to profoundly influence the overall evacuation dynamic. Groups are associations of people that form to jointly confront a hazardous situation. Groups can be made up of close friends, work colleagues or strangers. The group may be tightly or loosely coupled and the size of the group may vary, increasing or decreasing in size during the event. Groups can exert an influence on a range of evacuation parameters [4] such as;

Response times: Being a member of a group may reduce or increase average group member response times as members of the group are either encouraged to react quickly or are forced to wait for slow responders. This may have an impact on other individuals or groups as they observe the behaviour of the group.

Travel speeds: The group may travel at the speed of the slowest member of the group and may physically or psychologically assist the slowest member of the group to quicken their pace. Large groups of slowly moving people may also create blockages to other more rapidly moving individuals or groups within confined spaces.

Way Finding: Collective decision making by groups may improve the way finding ability of the individuals involved. It can also exert an influence on the decisions made by others not associated with the group as individuals may follow the lead set by larger groups of people.

An example from the database of a group being slowed during pre-evacuation is provided by the experience of a disabled occupant from the 69th floor of WTC1. The disabled occupant was a member of a group of 10 work colleagues. During the pre-evacuation phase all 10 colleagues waited whilst an *evacu-chair* was collected and the disabled member of the group was loaded into the device from his regular electric wheel chair. They then proceeded down the stairs together as a group. In doing so colleagues took it in turns to operate the *evacu-chair*. Thus they all proceed slowly during the evacuation.

Another example of a group slowing pre-evacuation was of two colleagues eating breakfast on the 44th sky lobby of WTC2. Having heard the impact into WTC1 they proceeded up the tower to the 80th floor so that one of them could collect his belongings. Again, both members of the group were delayed as a consequence of the desire to stay together.

In this section the frequency of group formation during the evacuation will be examined. In this investigation, the types of people that formed groups, i.e. were they colleagues, friends or strangers, and the size of the groups that were formed will be studied. Group cohesion during evacuation, i.e. did the groups remain intact, will also be investigated.

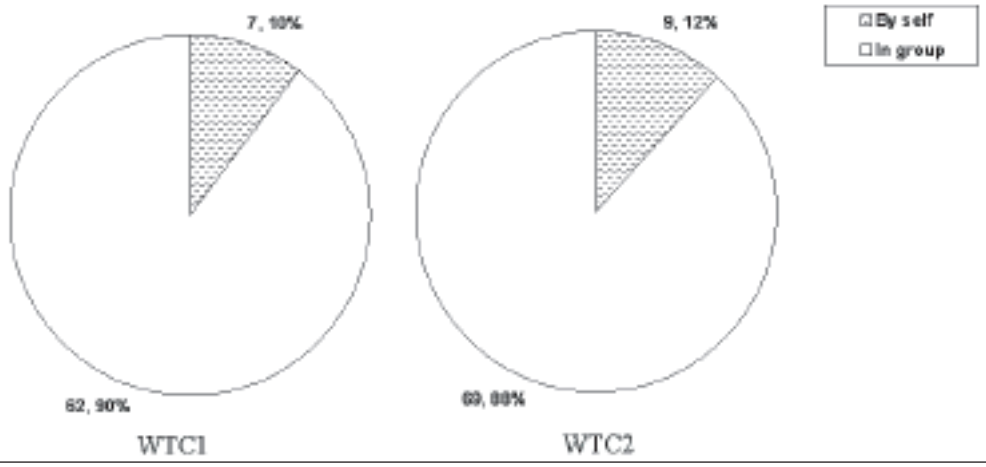
7.4.1 Group formation

This section will focus on group formation during pre-evacuation. Within the database there are 250 reported accounts describing 260 people. Of these 120 people were located in WTC1 and 119 were in WTC2, the remainder were from unknown origins. All these accounts will be examined in this analysis.

Of the 120 accounts of people from WTC1, 57% (69/120) specified sufficient detail to allow a judgement as to whether or not they were part of a group while 17% (20/120) provided insufficient information. The remaining 25.8% (31/120) occupant accounts were from occupants that could not evacuate as they were above the impact floors or within close proximity to the impact zone. Since we are interested in formation and cohesion of groups these people have been excluded from this analysis. Of the 119 accounts of people from WTC2 we could make a judgement concerning 66% (78/119) of the accounts. The remaining 34% (41/119) either provided insufficient detail or were not able to evacuate and so are not considered in this analysis.

Of the WTC1 accounts that allowed an assessment of group formation to be made, 90% (62/69) suggested the formation of some type of group during the pre-evacuation phase. In WTC2 a similar trend was noted with 88% (69/78) of the population describing forming some kind of group. Only 10% (WTC1) and 12% (WTC2) of occupants that made an evacuation reported evacuating by themselves (see Figure 29).

Figure 29: **Percentage of occupants that formed group(s) or evacuated by self during the pre-evacuation phase**



Of those occupants that reported forming groups within WTC1, 24% (15/62) did not report the size of the group. The remaining 47 occupants formed 16 distinct groups. In WTC2 28% (22/78) did not report the size of the groups formed while the remaining 56 occupants formed 21 distinct groups.

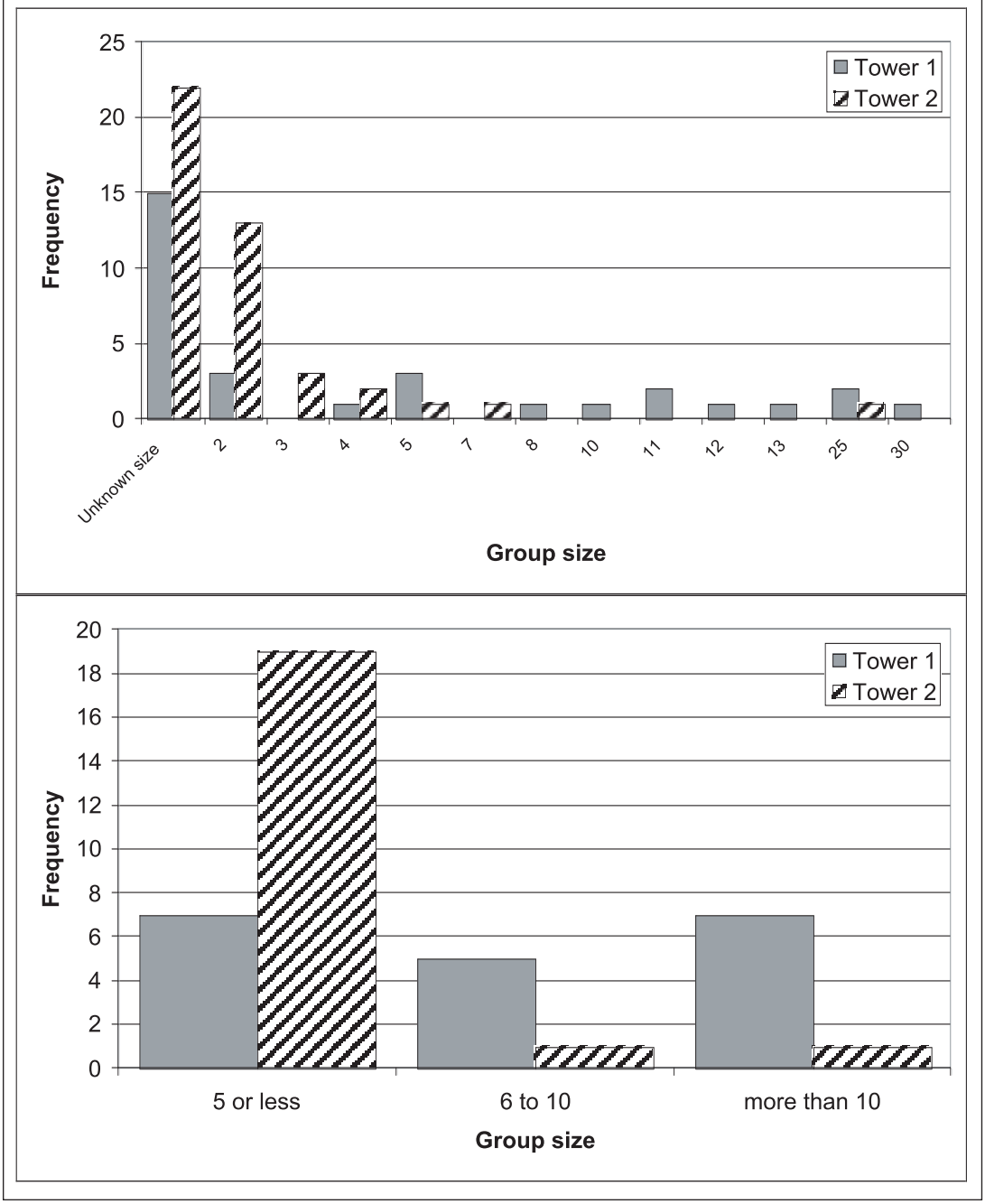
Table 26: **Summary of group sizes formed during PRE-EVACUATION**

Group size	WTC1	WTC2
Unknown size	15	22
2	3	13
3	0	3
4	1	2
5	3	1
7	0	1
8	1	0
10	1	0
11	2	0
12	1	0
13	1	0
25	2	1
30	1	0

The group size formed during the pre-evacuation phase is summarised in Table 26 and Figure 30. Clearly group sizes varied considerably both within the towers and between the towers with group sizes varying from 2 up to 30. In order to analyse the distribution of group sizes we arbitrarily define three categories of group sizes. Groups with less than 5 people are defined as small, groups consisting of 6 to 10 people are classed as medium and group consisting of more than 10 are large (see Figure 30).

Using this system, it is noted that 90% (19/21) of the groups in WTC2 were small and very few large groups formed. Indeed, 62% (13/21) of the groups that formed involved only two people. In contrast in WTC1 we find that group sizes tended to be more evenly distributed between small, medium and large (see Figure 30).

Figure 30: **Plot of groups sizes formed during pre-evacuation during PRE-EVACUATION**



This is reflected in the average group size (see Table 27) where the average group in WTC1 consisted of 10.6 while in WTC2 the average group size was 5.0. In WTC2, apart from one reported group of 25 people, the next largest consisted of 7 people. If we exclude the 25 person group, we find that the average group size for WTC2 is 3.4 people.

Clearly the evacuation dynamics in both towers were different. In WTC1 the evacuation was more concerted having started directly as a result of the attack on their building. People formed large groups for mutual support and protection. In WTC2, the majority of the accounts in the data base concern individuals who started the evacuation prior to WTC2 being attacked. These people were not subjected to direct danger and so there was less need to find security in large groups.

Table 27: **Breakdown of group formation details for those accounts that contained sufficient detail to make a judgement on group formation**

	WTC1	WTC2
Number of accounts	69	78
On own	7 [10%]	9 [12%]
In group	62 [90%]	69 [88%]
Number of groups	31	43
Unknown size	15	22
Known sizes	16	21
Average group size	10.6	5.0

7.4.2 Group composition

The nature of the group make up is examined in this section. Unfortunately, insufficient detail is available within occupant reports to form firm conclusions concerning this aspect of group dynamics. It was not possible to make a judgement on the relationship between group members for 55% (34/62) and 58% (36/78) of accounts that reported group information from WTC1 and WTC2 respectively (see Table 28).

Of those that did provide information regarding group composition, 79% (22/28) of accounts from WTC1 and 81% (34/42) of accounts from WTC2 described groups consisting of employees from the same office. A further 18% (5/28) and 5% (2/42) of accounts from WTC1 and WTC2 described groups consisting of a mixture of colleagues from the same office and individuals from other offices.

Table 28: **Summary of group composition information**

Group composition	**WTC1**	**WTC2**
Same office	22 [35%]	34 [55%]
Same office + other offices	5 [8%]	2 [3%]
Different office	0 [0%]	3 [5%]
Other	1 [2%]	3 [5%]
Insufficient information	34 [55%]	36 [58%]
Total	62	78

Whilst informative, some of the accounts came from the same group and referenced each other, i.e. for a group containing A, B and C, A was colleague with B and C, B was colleague with A and C, etc. This may have unduly biased the data towards a particular finding and given to much weight to a particularly detailed account of a particular group. Given this it is perhaps more meaningful to consider a group as a single entity rather than each individual account within a particular group. In this manner we would assign one description to each group based on their composition. In essence we treat the group as the unit of analysis rather than the individuals.

If we treat each group as an entity we find that 80% (12/15) and 71% (20/28) of groups in WTC1 and WTC2 consisted of employees from the same office and 13% (2/15) and 18% (5/28) of groups consisted of a mixture of office and adjacent office employees (see Table 29).

The data suggests that initially groups predominately comprised of colleagues from the same offices rather than mixtures of employee from other locations. This information combined with the group size information may suggest that in WTC2 evacuation decisions were taken on a local/personal basis perhaps involving small localised groups of colleagues. In contrast, in WTC1 larger groups tended to form and this may have been based on collective decisions centralised on an office basis.

Table 29: **Summary of group composition information EXCLUDING UNKNOWNs**

	Number of accounts		Number of groups involved	
Group composition	**WTC1**	**WTC2**	**WTC1**	**WTC2**
Same office	22 [35%]	34 [55%]	12 [80%]	20 [71%]
Same office + other offices	5 [8%]	5 [8%]	2 [13%]	5 [18%]
Other	1 [2%]	3 [5%]	1 [7%]	3 [11%]
Insufficient information	34 [55%]	36 [58%]		
Total	62	78	15	28

7.4.3 Group leaders

A number of accounts identified individuals that took control of the group. These individuals appear to have taken responsibility for the group and instigated the evacuation process. Unfortunately for most groups there was insufficient data to identify group leaders. For 71% (44/62) of the accounts from occupants in groups in WTC1 it was not possible to determine the identity of the group leader. This was also true for 79% (49/78) of occupants from WTC2 (see Table 30).

For the groups that did provide sufficient information, 67% (12/18) of accounts described their line manager as leading groups for WTC1 and 76% (22/29) in WTC2 (see Table 30). However, some of these accounts were from individuals within the same groups. If we consider the number of groups for which we have sufficient information, then 58% (7/12) of these groups in WTC1 and 67% (12/18) of these groups in WTC2 were led by senior authority figures. From the available accounts it was only possible to determine that one of the line managers was a formal line manager. **This suggests that the vast majority of groups, for which there is sufficient information, were led by their line manager during pre-evacuation.**

Clearly, organisational managers and authority figures are likely to be figures of authority in emergency situations and so they should be well versed in emergency procedures.

Between a third and a half (42% (5/12) for WTC1 and 33% (6/18) for WTC2) of the groups for which we can identify a group leader were not led by their line managers. This was mainly due to the composition of the groups (see Table 31). In WTC1 five groups were not led by line managers. Two of these groups were composed of office staff from the same office and were led by a colleague from the group. The group composition of another group could not be determined although the data suggests that a line manager did not lead the group. The remaining two groups appeared not to have a leader.

Table 30: **Summary of group leader information from the database**

Group leader	WTC1	WTC2
Line Manager	12 [19%]	22 [35%]
Not line manager	3 [5%]	6 [10%]
No leader	3 [5%]	1 [2%]
Insufficient information	44 [71%]	49 [79%]
Total	62	78

In WTC2, six groups were not led by line managers. Three of these groups were comprised of people from different offices and were led by regular employees. 1 group contained visitors who formed a group to evacuate – again the leader was not a line manager but a visitor. A fifth group was comprised of people from the same office and other adjacent offices. Again this group was led by regular employees. The final group did not appear to have a leader.

Table 31: **Summary of group leader information EXCLUDING UNKNOWNs**

	Number of accounts		Number of groups involved	
Group leader	**WTC1**	**WTC2**	**WTC1**	**WTC2**
Line Manager	12 [67%]	22 [76%]	7 [58%]	12 [67%]
Not line manager	3 [17%]	6 [21%]	3 [25%]	5 [28%]
No leader	3 [17%]	1 [3%]	2 [17%]	1 [6%]
Total	18	29	12	18

7.4.4 Those that evacuated by themselves

The majority of people within the database suggest that they evacuated as a member of a group. The data in Table 27 suggests that, of those that gave an indication of who they were with, only 10% (7/69) of the people in WTC1 and 12% (9/78) in WTC2 suggested that they evacuated on their own.

The accounts from WTC1 suggest that those occupants who evacuated on their own were not in their normal work areas and thus not exposed to friends, colleagues or acquaintances. Most were alone or with total strangers at the T1 impact. For example, Brian Bernstein was located on the 38th floor of WTC1 in an office on his own. Having heard and felt the impact he grabbed a few items and immediately left. Another, Tom Canavan was on the 47th floor of WTC1 and also evacuated by himself. He was with colleagues at the time of the impact but delayed his evacuation to *"help put securities back in the vault"*. He sent his colleagues on without him. A third example came from Richard Prescott Stearns who worked in a windowless server room on his own.

7.4.5 Group cohesion during descent

An attempt was made to determine whether or not once formed, groups remained in tact throughout the descent, expanded is size or contracted and if so, whether or not this occurred voluntarily or as a result of events during evacuation. The following categories were used to aid the analysis.

Expanded	Indicates whether a group increases in size with occupants other than those that initially set out together.
Rejoined	Indicates whether a group that separated was later rejoined by the people were separated from the group. Separation of group members could be due to presence of smoke or congestion.
Intact	Indicates that a group remained intact throughout the descent without losing or gaining group members.
Reduced	Indicates that a group decreases in size, whether intentionally or unintentionally.
Intentionally split	Indicates that a group made a conscious and intentional decision to split. This includes behaviour such as some group members deciding to take a break, change stairs or return to their office.
Unintentionally split	Indicates that a group unintentionally decreased in size due to events. An example of this would be a group being separated in dense congestion.

Clearly, some of the above categories are not mutually exclusive. For example, a group may have expanded, then contracted intentionally then further contracted perhaps unintentionally. Thus a single group may have experienced a number of cohesion categories during the descent and so be entered into several categories.

Before discussing the results, recall that 31 groups were identified in WTC1 and 43 groups in WTC2. Of these the group size could be estimated for 51% (16/31) and 49% (21/43) of the groups for WTC1 and WTC2 respectively (see Table 27). Determining whether groups expanded, split or remained intact was extremely difficult for groups whose size was unknown at the start of the evacuation (see Table 26). However in some instances this was possible. Even when the group size was known, it was difficult to make judgements on whether groups sizes changed during the evacuation. In total it was possible to determine group cohesion information for 10/31 (32%) of the potential groups in WTC1 and 20/43 (47%) of the potential groups for WTC2.

Table 32: **Summary of group cohesion during EVACUATION**

	WTC1	WTC2
# of groups that provided useful information	10	20
# of groups that did not provide useful information	21	42
Expanded	2 [20%]	11 [55%]
Rejoined	1 [10%]	0 [0%]
Intact	4 [40%]	4 [20%]
Reduced	6 [60%]	8 [40%]
Intentionally split	4 [40%]	4 [20%]
Unintentionally split	2 [20%]	1 [5%]
[ ] represents percentages of population for which information available		

In WTC1, 60% (6/10) of the groups split at some stage during their evacuation and 40% (4/10) remained intact throughout the evacuation. Of the groups that split, 67% (4/6) did so intentionally. The reasons cited were, some occupants deciding to use another stairwell, one occupant deliberately slowing their speed but ushering others onwards (this occupant later joined another group), one occupant deciding to rush on ahead of the group; a reason could not be determined for one of the instances. A third (2/6) of the groups that split did so unintentionally. One group split as a result of group member(s) getting lost due to heavy congestion resulting in the "human chain" breaking. Only one group separated and rejoined. This was a relatively small group of four colleagues who regrouped at the 78th floor. A further two groups separated but were joined by strangers. The first incident involved a woman who became tired and urged her group of 11 to go on ahead whilst she rested. She was picked up reluctantly by two strangers who stayed with her for the remainder of the evacuation. Another group of office workers (unknown size) became separated whilst moving through smoke, they later joined with strangers for the duration of the evacuation.

In WTC2, 40% (8/20) of the groups split at some stage during the evacuation and 20% (4/20) remained intact throughout. Some 55% (11/20) of the groups expanded at some stage during their evacuation. Of the groups that contracted in size, 50% (4/8) split intentionally and 13% (1/8) split unintentionally. The precise rationale for 38% (3/8) of the groups that split could not be determined. The unintentional split occurred in smoke conditions whilst attempting a rescue effort on the stairs. The intentional splits occurred for the following stated reasons: a group split due to one member not wanting to wait to use an elevator, another group split while some group members assisted an injured women, another group split as a result of hearing the announcement over the PA (saying that there was no need to evacuate) and the remaining group split at the sky lobby as a fire marshal decided to go back to the offices to assist more people.

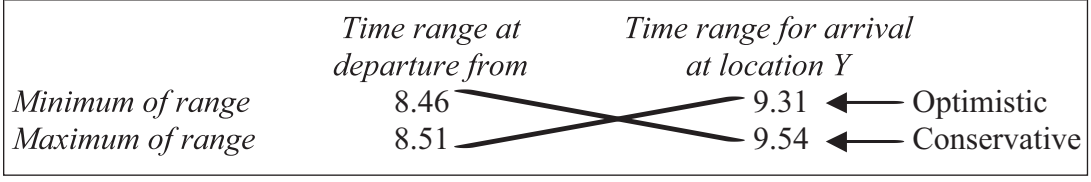
In WTC2 there were 11 reported instances of groups increasing in size during the evacuation. Of these 5 groups were joined by strangers, 1 by a small (eight year old) child and the remaining 5 groups were all joined by colleagues that were known to the group members. There were no reported instances of groups rejoining after having been separated.

The strongest conclusion from this analysis is that group sizes were dynamic in nature, expanding and contracting during the evacuation. When groups contracted in size, the predominate reason for this was the deliberate action of a group member, not adverse environmental or situational conditions forcing a group to split. In WTC1, the groups that formed tended to be large with a significant number splitting during the (6/10) descent, primarily for deliberate and individual reasons. In WTC2, the groups tended to be smaller in size with a smaller proportion of these groups splitting during the descent (8/20). Here again, the predominant reasons for breaking the group were based around deliberate actions by groups members.

7.5 ESTIMATING A RATE OF DESCENT

In order to calculate a descent rate it was necessary for occupants to specify approximately where they were at a two different times, preferable some distance apart. Unfortunately in most instances occupants were unable to define the time that they begun evacuating and/or where they were at specific times. Indeed, only 24 reports provided enough detail to attempt a calculation of descent movement rate. Furthermore, most of these accounts failed to provide a suitable time reference at a specific location. For many accounts a time range could be determined. As such, these accounts had both an upper and lower bound to each time reference, i.e. *"I was at floor 24 sometime between 8:46 and 8:51"*. Two measures were devised for these occupants. One measure was termed 'conservative' and represents the difference between the earliest estimated departure time and the latest estimated arrival time (see Figure 31). This measure represents the estimated maximum reported time to travel between the two locations. The second measure is termed 'optimistic' and represents the difference between the latest estimated departure time and the earliest estimated arrival times (see Figure 31). This time represents the shortest reported time period to travel between to locations.

Figure 31: **Method of calculating optimistic and conservative times between two locations**



Another difficulty was the degree of variability in the level of detail provided in occupant reports. Whilst some accounts may have specified their action at a specific time marker they would only provide a vague description of their location (for example, between the 2nd and 44th floors). Similarly, reports that specified precise markers and locations for departure and arrival (for example "I left floor 102 at 9:02 and evacuated at 9:45") may include numerous non-movement actions during the descend (for example, leaving the stairs to make a phone call in a conference room, stopping to get a drink, etc.). Where the data was grossly unreliable (e.g. *'I was somewhere between the 2nd and 44th floor'*), it was excluded from further analysis. The remaining data was assigned a level of reliability according to the accuracy of, the markers and locations specified for departure and arrival and the number of obstructions and non-movement actions undertaken during evacuation.

Based on these factors each data point was classified as either:

- **Reliable:** Markers and locations well known and there was little extraneous actions *en route*.
- **Less reliable:** Markers and/or location were not well known but time references had relatively small ranges and/or there were some extraneous actions *en route*.
- **Unreliable:** Markers and/or locations were not well known and time references had large ranges and/or there were numerous extraneous actions *en route*.

Some occupants specified a single departure time but had a range for arrival times or *vice versa*. The optimistic measure was taken as the shortest travel time and the conservative as the longest travel time. Occupants that specified exact timings for both departure and arrival were included in both the conservative and optimistic datasets.

Finally for some occupants a time estimate based on the event markers provided within the database were available as well as a time estimate provide by the occupant in their account. For example, John Balcer stated that it took 15 minutes to descend from the 61st floor. In addition to his estimate of the travel time, it was possible to use event markers within the database to estimate his location at various times. Using this approach, it was determined that Balcer started his evacuation shortly after T1 (S>T1 i.e. between 8:46 and 8:51) and arrived at ground level some time after T2 (>T2, i.e. 9:08 to 9:31). Thus his travel time using the markers was optimistically 17 minutes and conservatively 46 minutes. When estimated data from the database is available in addition to stated lengths of time both have been included as different data-points for analysis.

7.5.1 An estimated rate of descent measured in floors/minute

Using the above scheme it was possible to calculate an approximate measure of the rate of descent for 17 occupants in WTC1 and 12 occupants in WTC2. Furthermore, in some accounts sufficient time/location references existed to sub-divide their movement into two portions, i.e. time from X to Y and then from Y to Z. These are referred to as movement phases. In total 4 reliable accounts were available for WTC1 and 4 for WTC2. These accounts yielded 5 distinct movement phases for WTC1 and 7 distinct movement phases for WTC2. Of the less reliable data, 8 accounts yielded 10 distinct movement phases for WTC1 and 3 accounts yielded 4 distinct movement phases for WTC2. For each tower there were 5 unreliable accounts that yielded 5 distinct movement phases (see Table 33).

Table 33: **Summary of available movement rate data**

	WTC1		WTC2	
	Accounts	**Movements**	**Accounts**	**Movements**
Reliable	4	5	4	7
Less reliable	8	10	3	4
Unreliable	5	5	5	5

Thus from the 17 suitable occupant reports in WTC1, some 20 distinct movement phases and time measures were available (see Table 34) for analysis and from the 12 suitable occupant reports for WTC2, another 16 distinct movement phases and time estimates were available (see Table 35).

It is apparent from the data available for WTC1 (see Table 34) that numerous non-evacuation movement actions were undertaken during most occupant's descent. They ranged from having to back track due to a locked door(s) or having to stop to let firemen or injured past to suffering fatigue symptoms and stopping to take a break. Most accounts described congestion and some also described changing staircases. In addition, some encountered water and smoke on the stairs. For WTC2 some left the stairs after hearing the P/A announcement while others met occupants making their way up the stairs (see Table 35). Some also back tracked and climbed stairs during their evacuation, some encountered firefighters and or/injured on the stairs, whilst others took breaks and rested.

Table 34: **Descent rate data and limitations for WTC1 extracted from occupant accounts**

Number	Name	Optimistic travel time (minutes)	Conservative travel time (minutes)	Floors	Worst rate fl/min	Best rate fl/mn	Summary of flow conditions	Non-evacuation movement notes
Reliable	Genelle	20	20	51	2.5	2.5	Free flowing	survived collapse, met firefighters coming up stairs, used B
Reliable	Dharam Pal	40	45	71	1.6	1.8	Congested	Met congestion, stairs crowded
Reliable	Dharam Pal	40	40	71	1.8	N/A	Congested	Explicit 40 minute descent, met congestion, stairs crowded
Reliable	Brian Bernstein	17	22	35	1.6	2.1	Congested	Stopped numerous times, met firefighters and congestion
Reliable	Brendan McWade	17	22	37	1.7	2.1	Congested	Made way for firefighters
Unreliable	Adam Mayblum	61	68	84	1.2	1.4	Congested	Used A from 53rd floor, Made way for injured and firefighters
Unreliable	Steve McIntyre	56	68	88	1.3	1.6	Congested	Met firefighters, changed stairs, switched stairs, opened doors of stair well
Unreliable	Shivam Iyer	29	29	35	1.2	1.2	Unknown	no delays stated
Unreliable	Shivam Iyer	15	24	12	0.5	0.8	Unknown	no delays stated
Unreliable	Yvette Thompson	63	73	84	1.2	1.3	Unknown	Met locked door on stairs, met firefighters coming up
Unreliable	Christian Saeboe	35	35	36	1.2	1.2	Congested	Stated exactly half hour to evacuate, met big queues
Unreliable	Chuck Allen	35	49	80	1.6	2.3	Congested	Met congestion, met locked door, met firefighters
Unreliable	Claudia Robichaud	5	12	22	1.8	4.3	Unknown	Could not tell final time too clearly
Unreliable	Claudia Robichaud	5	28	27	1.0	5.5	Unknown	Could not tell final time too clearly
Unreliable	John Labriola	33	63	68	1.1	2.1	Congested	Met firefighters, injured, stopped occasionally, met water on stairs
Dubious	Claire McIntyre	40	45	88	1.9	2.2	Congested then faster	crossing at transfer
Dubious	Tom Conavan	33	40	45	1.1	1.4	Congested	Got stuck in heavy congestion
Dubious	Juliette Bergman	40	45	80	1.8	2.0	Fast	Suffered cramp, gave way for injured
Dubious	Cathy Pavelec	33	40	64	1.6	1.9	Unknown	Met firefighters
Dubious	Jan Khan	33	40	80	2.0	2.4	Congested	Met firefighters

From the data presented in Table 34 and Table 35 stair descent rates (floors/minute) can be calculated. These are summarised in Table 36 and presented graphically in Figure 32. Most accounts yielded two data-points which are both presented in Figure 32. The first represents the optimistic estimate (shown as a white marker) and the second the conservative estimate (shown as a black marker). For accounts that specified precise timings only the optimistic values are presented. Finally the x-values of the data-points merely spread the plots to aid legibility.

It can be seen from Figure 32 that the reliable data for WTC1 is tightly clustered at 1.8 floors/minute (conservatively) and 2.1 floors/minute (optimistically). The fastest descent rate was 2.5 floors/minute and was achieved by an occupant (Genelle Guzman-McMillan) who began her evacuation at 10:08 and moved under essentially free-flow conditions. Jake Pauls [5] suggests that a stair descent rate of 3.0 floors/minute would represent a slow-moderate speed in high-rise buildings. Clearly, the stair descent rates determined for WTC1 are significantly below this value. In contrast the data from WTC2 appears to be less well clustered with reliable data suggesting a mean conservative rate of 2.1 floors/minute and an optimistic mean rate of 3.0 floors/minute.

Table 35: **Descent rate data and limitations for WTC2 extracted from occupant accounts**

Number	Name	Optimistic travel time (minutes)	Conservative travel time (minutes)	Floors	Worst rate fl/min	Best rate fl/mn	Summary of flow conditions	Non-evacuation movement notes
Reliable	Magdalena Brown	33	63	88	2.7	1.4	< 44 good speed	Stopped a couple of times
Reliable	Russell Moskowitz	33	63	77	2.3	1.2	Congested	Stopped, Left stairs at P/A announcement
Reliable	Russell Moskowitz	30	30	77	2.6	2.6	Congested	Stopped, Left stairs at P/A announcement, stated it took 30 minutes
Reliable	John Balcer	17	N/A	59	3.5	1.3	Congested	Stated that it took 25 minutes
Reliable	John Balcer	25	25	59	2.4	2.4	Congested	Stated that it took 25 minutes
Reliable	Christopher Wiener	12	12	53	4.4		Congested	Said it took 15 minutes
Reliable	Christopher Wiener	15	15	53	3.5	3.5	Unknown	Said it took 15 minutes
Less reliable	Eric Levine	33	63	61	1.8	1.0	Congested/ fast below 30	Surging flow caused crush and stoppage, had asthma attack
Less reliable	Richard Fern	23	51	82	3.6	1.6	Few in stairs	Met debris, had to switch stairs
Less reliable	Gigi Singer	23	23	25	1.1	1.1	Unknown	Stated it took 10 minutes to descend to the 78th
Less reliable	Gigi Singer	23	23	38	1.7	1.7	Unknown	Met debris, met firemen
Unreliable	Judy Wein	40	68	63	1.6	0.9	Unknown	Left stairs, met firemen
Unreliable	Cara LaTorre	33	63	98	3.0	1.6	Little congestion	Took shoes off, left at announcement, fatigue effect, met injured
Unreliable	Kelly Reyher	33	63	98	3.0	1.6	Unknown	Left stairs (twice)
Unreliable	Donna Spira	40	68	98	2.5	1.4	Unknown	Back tracked, went upwards, Left stairs, met physical blockage
Unreliable	Bryan Charles	40	68	68	1.7	1.0	Congested	Flow stopped

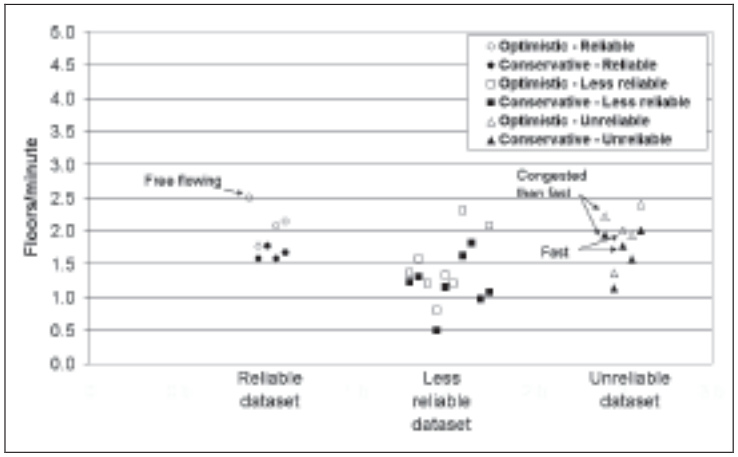
Table 36: **Summary of descent rate (floors/minute) data for both towers**

		Reliable floors/min	Less reliable floors/min	Unreliable floors/min	All floors/min	All – excluding unreliable floors/min
WTC1	Min	[1.6] (1.8)	[0.5] (0.8)	[1.1] (1.4)	[0.5] (0.8)	[0.5] (0.8)
	Max	[2.5] (2.5)	[1.8] (5.5)	[2] (2.4)	[2.5] (5.5)	[2.5] (5.5)
	Mean	[1.8] (2.1)	[1.2] (2.2)	[1.7] (2.0)	[1.5] (2.1)	[1.4] (2.1)
	Data points	[5] (5)	[10] (10)	[5] (5)	[20] (20)	[15] (15)
WTC2	Min	[1.2] (2.3)	[1.0] (1.1)	[0.9] (1.6)	[0.9] (1.1)	[1.0] (1.1)
	Max	[3.5] (4.4)	[1.7] (3.6)	[1.6] (3.0)	[3.5] (8.2)	[3.5] (8.2)
	Mean	[2.1] (3.0)	[1.3] (2.0)	[1.3] (2.3)	[1.6] (2.9)	[1.8] (3.1)
	Data points	[6] (7)	[4] (4)	[5] (5)	[15] (16)	[10] (11)

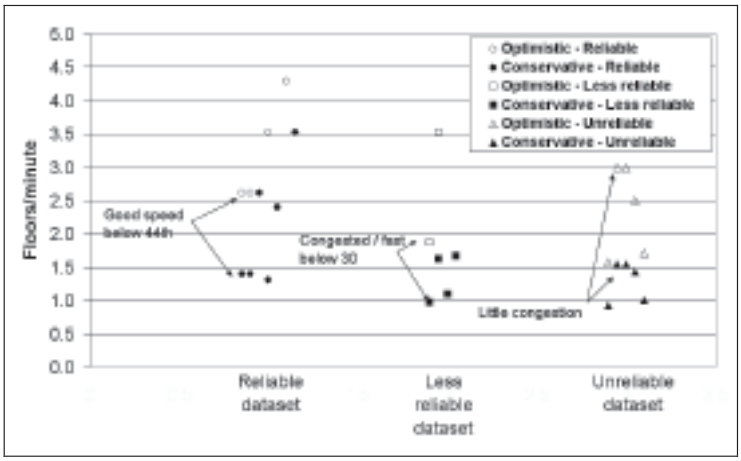
[ ] = conservative estimate, ( ) = optimistic estimate

The increased descent rate in WTC2 may have resulted from reduced levels of congestion on the stairs (see section 7.1) and the absence of significant amounts of water at the time that the accounts were made (see section 7.2.6). Here it is important to recall that 45% of the WTC2 accounts relate to occupants who commenced their evacuation prior to T2 (see section 6.1).

Figure 32: **Estimated floors/minute for WTC1 and WTC2**



WTC1



WTC2

Most of the reliable and less reliable data used in estimating the descent rates in WTC1 originated from evacuations that started early in the evacuation process, just after T1. It is likely that these people would have encountered heavy congestion on the stairs. In WTC1, 53% of the people started their evacuation just after T1 and 81% started their evacuation just before T2. Indeed, most of the people in this sample reported delays and some undertook non-descent actions. The main reported delays were meeting firefighters (9 accounts) and congestion (6 accounts, 4 from the reliable data set). Other less frequently reported delays involved encountering locked doors along the evacuation route and having to move aside to let the injured pass. Only one person in this group described experiencing no delays.

In estimating the descent rates in WTC2, all of the reliable data originated from evacuations that started shortly after T1 and before T2. However the data from the less reliable data set originates from much more varied evacuations, some starting prior to T2 and some after T2. There were only 2 accounts in the WTC2 dataset that reported meeting firefighters coming up the stairs and 6 accounts of congestion on the stairs (5 of these were from the reliable data set), a further 4 data points involved little congestion.

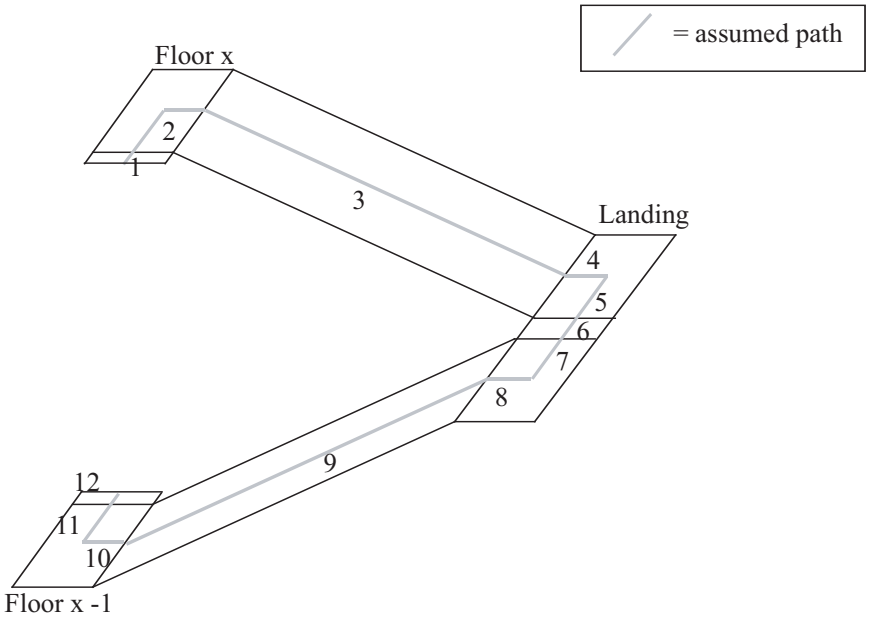
7.5.2 An estimated rate of descent in metres per second

A more general measure of movement rate is the average movement velocity or travel speed. To estimate the movement speed it is necessary to estimate the travel distance that each occupant traversed between two locations. Unfortunately, the data available from the occupant accounts made this rather difficult. Indeed, in most accounts it was not possible to determine which staircase was used, yet alone whether occupants travelled down the inner or outer path on the stairs. Compounding this difficulty, some occupants undertook non-evacuation movement actions during their descent.

Given these limitations an estimate was calculated based on the assumption that occupants moved down the centre line of the staircase and includes non-evacuation movement time but not additional distances that may have been incurred. As such the estimate of travel speed in this study represents an *average* travel speed in a continuous line down the centre of the stairs from location X to location Y. As detailed floor plans of the buildings were not available for this study, estimates of stair geometries were made from various published sources containing the dimensions of stair geometries.

From published literature the slope of the stairs was 38.3 degrees and that the height of non-machine floors was 3.65 m and machine floors was 4.27 m. Using these figures the diagonal length from floor to floor as 7.55 m and 6.46 m for machine and non-machine floors respectively. The width of the stairs varied, Staircase B had a width of 140 cms and staircase A and C both had widths of 110 cms. The stairs themselves were dog-legged with a landing between each run. The width of the landings was 300 cms on staircase B and 254 cms on staircase A and C. Given the width of the stairs and landings it is assumed that there was a space between each run of 20 cms on staircase B and 34 cms on staircases A and C (see distance 6 in Figure 33). The depth of the landings could not be found in the literature and so it was assumed that the landings were as deep as the stairs were wide (i.e. depths of 140 cms for staircase B and 110 cms for staircases A and C).

Figure 33: **Assumed travel path down the stairs**



The distance through the landing onto the stair runs is calculated as (1) _ middle gap + (2) _ landing width + (3) _ landing depth. The distance down the first run of stairs is calculated as (3) _ diagonal length. The distance through the landing is then calculation as (4) _ landing width (away from the stairs) + (5) _ stair width + (6) middle gap + (7) _ a stair width (moving across the landing) + (8) _ landing width (towards the stairs). The distance down the second run of stairs is then calculated as (9) _ diagonal length and the distance onto the landing so as to finish the same point as the start is calculated as (10) _ landing width (moving away from the stairs and onto the landing) + (11) _ a stair width + (12) _ and middle gap (moving across the landing).

Table 37: **Measurements used in calculating travel distances down stairs**

Distance	Machine floor (m)	Non Machine floor (m)
Diagonal distance	7.55	6.46
Total landing traversal distances if using stair B	3.2	3.2
Total landing traversal distances if using stair A or C	2.88	2.88
Total distance if using stair B	10.75	9.66
Total distance if using stair A or C	10.43	9.34
Average distance of B and A	10.59	9.50

The idealised route taken by occupants is assumed to consist of travelling down the centre of the stairs and passed through the centre of the landings (see Figure 33). Similarly, the length of the stair transfer corridors (protected horizontal corridors used to reposition stairs within the building) were not known. Based on material published in *USA Today*, it is estimated that these transfer corridors were between 10-35 metres in length.

Table 38: **Descent travel speed data and limitations for WTC1 calculated from accounts**

Confidence	Name	Distance (m)	Optimistic travel time (min)	Conservative travel time (min)	Optimistic movement rate (m/s)	Conservative movement rate (m/s)	Flow conditions	Non-evacuation movement notes
Reliable	Genelle	486	20	20	0.41	0.41	Free flowing	survived collapse, met firemen coming up stairs, used B
Reliable	Dharam	679	40	45	0.28	0.25	Congested	Met congestion, stairs crowded
Reliable	Dharam	679	40	40	0.28	0.28	Congested	Explicit 40 minute descent, met congestion, stairs crowded
Reliable	Brian Bertstien	335	17	22	0.33	0.25	Congested	Stopped numerous times, met firemen and congestion
Reliable	Brendan McWade	354	17	22	0.35	0.27	Congested	Made way for firemen
Less reliable	Adam May	796	61	68	0.22	0.2	Congested	Used A from 53rd floor, Made way for injured and firemen
Less reliable	Steve McIntyre	842	56	68	0.25	0.21	Congested	Met firemen, changed stairs, switched stairs, opened doors of stair well
Less reliable	Shivam Iyer	335	29	29	0.19	0.19	Congested	no delays stated
Less reliable	Shivam Iyer	116	15	24	0.13	0.08	Unknown	no delays stated
Less reliable	Yvette Thompson	804	63	73	0.21	0.18	Unknown	Met locked door on stairs, met firefighters coming up
Less reliable	Christian Saeboe	344	35	35	0.16	0.16	Unknown	Stated exactly half hour to evacuate, met big queues
Less reliable	Chuck Allen	766	35	49	0.36	0.26	Congested	Met congestion, met locked door, met firemen
Less reliable	Claudia Robichaud	221	5	12	0.74	0.31	Congested	Could not tell final time too clearly
Less reliable	Claudia Robichaud	249	5	28	0.83	0.15	Unknown	Could not tell final time too clearly
Less reliable	John Labriola	650	33	63	0.33	0.17	Unknown	Met firemen, injured, stopped occasionally, met water on stairs

Table 38 *(Continued)*: **Descent travel speed data and limitations for WTC1 calculated from accounts**

Confidence	Name	Distance (m)	Optimistic travel time (min)	Conservative travel time (min)	Optimistic movement rate (m/s)	Conservative movement rate (m/s)	Flow conditions	Non-evacuation movement notes
Unreliable	Clair McIntyre	814	40	45	0.34	0.3	Congested	crossing at transfer
Unreliable	Tom Canavan	432	33	40	0.22	0.18	Congested then faster	Got stuck in heavy congestion
Unreliable	Juliette Bergman	766	40	45	0.32	0.28	Congested	Suffered cramp, gave way for injured
Unreliable	Cathy Pavelec	612	33	40	0.31	0.26	Fast	Met firefighters
Unreliable	Jan Khan	766	33	40	0.39	0.32	Unknown	Met firefighters

However, as it was not possible to determine which staircase each occupant used it was decided to ignore these distances in the travel speed estimates. Whilst not ideal, the impact of this omission is only likely to be small given the large distances that occupants travelled. Finally, for those occupants for which it was not possible to determine which staircase was used (i.e. most occupants), an average of the travel distance for the larger staircase (B) and the smaller staircase (A or C) was taken. A summary of the data used to calculate the distances down a run of stairs is presented in Table 37. The total estimated descent distance from the 110th floor to the stairwell exit on floor 2 was calculated as 1061 m when using staircase B and 1026 m if using staircases A or C.

Table 39: **Descent travel speed data and limitations for WTC2 calculated from accounts**

Confidence	Name	Distance (m)	Optimistic travel time (min)	Conservative travel time (min)	Optimistic movement rate (m/s)	Conservative movement rate (m/s)	Flow conditions	Non-evacuation movement notes
Reliable	Magdalena Brown	861	33	63	0.43	0.23	Free flowing	survived collapse, met firemen coming up stairs, used B
Reliable	Russell Moskowitz	738	33	63	0.37	0.20	Congested	Met congestion, stairs crowded
Reliable	Russell Moskowitz	738	30	30	0.41	0.41	Congested	Explicit 40 minute descent, met congestion, stairs crowded
Reliable	John Balcer	565	17	45	0.55	0.21	Congested	Stopped numerous times, met firemen and congestion
Reliable	John Balcer	565	25	25	0.38	0.38	Congested	Made way for firemen
Reliable	Christopher Wiener	508	12	N/A	0.71	N/A	Congested	Used A from 53rd floor, Made way for injured and firemen

Table 39 *(Continued)*: **Descent travel speed data and limitations for WTC2 calculated from accounts**

Confidence	Name	Distance (m)	Optimistic travel time (min)	Conservative travel time (min)	Optimistic movement rate (m/s)	Conservative movement rate (m/s)	Flow conditions	Non-evacuation movement notes
Reliable	Christopher Wiener	508	15	15	0.56	0.56	Congested	Met firemen, changed stairs, switched stairs, opened doors of stair well
Less reliable	Eric Levine	584	33	63	0.29	0.15	Unknown	no delays stated
Less reliable	Richard Fern	785	23	51	0.57	0.26	Unknown	no delays stated
Less reliable	Gigi Singer	237	23	23	0.17	0.17	Unknown	Met locked door on stairs, met firefighters coming up
Less reliable	Gigi Singer	365	23	23	0.26	0.26	Congested	Stated exactly half hour to evacuate, met big queues
Less reliable	Judy Wein	603	40	68	0.25	0.15	Congested	Met congestion, met locked door, met firemen
Less reliable	Cara LaTorre	937	33	63	0.47	0.25	Unknown	Could not tell final time too clearly
Unreliable	Kelly Reyher	937	33	63	0.47	0.25	Unknown	Could not tell final time too clearly
Unreliable	Donna Spira	937	40	68	0.39	0.23	Congested	Met firemen, injured, stopped occasionally, met water on stairs
Unreliable	Bryan Charles	650	40	68	0.27	0.16	Congested then faster	crossing at transfer
Unreliable	Donna Spira	937	68	40	0.23	0.39	Congested	Got stuck in heavy congestion
Unreliable	Bryan Charles	650	68	40	0.16	0.27	Fast	Suffered cramp, gave way for injured

The calculated travel speeds for WTC1 and WTC 2 are presented in Table 38 and Table 39 and summarised in Table 40. The summarised data points are presented in Figure 34. Most accounts yielded two data-points which are both presented in Figure 34. The first represents the optimistic estimate (shown as a white marker) and the second the conservative estimate (shown as a black marker). For accounts that specified precise timings only the optimistic values are presented. Finally the x-values of the data-points merely spread the plots to aid legibility.

Examining the reliable dataset for WTC1 suggests relatively slow movement speeds. The mean estimated average movement velocity is optimistically calculated as 0.33 m/s and conservatively calculated as 0.29 m/s. An occupant (Genelle Guzman-McMillan) that began descent at 10:08 and described her descent as *"free flowing"*, only attained an average estimated movement speed of 0.41 m/s. This average movement speed is below Pauls estimated movement velocity in his optimum density zone, i.e. 0.52 m/s [6]. All of the movement speeds are above Pauls crush density velocity of 0.22 m/s (see Table 40 and Figure 34) [6]. The spread of calculated movement speeds is 0.25-0.41m/s.

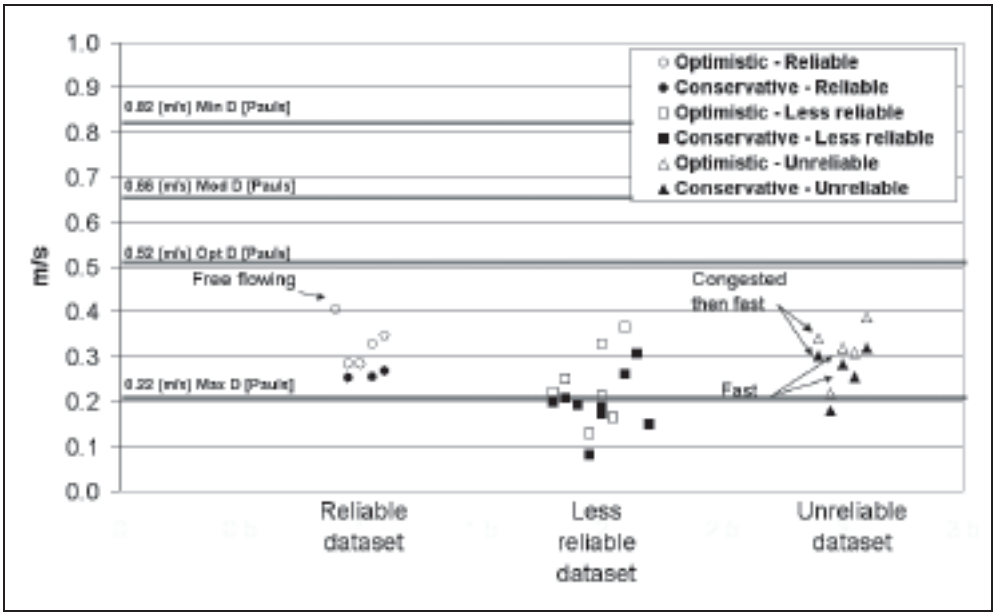
Table 40: **Summary of descent speeds**

		Reliable estimated average (ms)	Less reliable estimated average (m/s)	Unreliable Estimated average (m/s)	Estimated average (m/s) using all data	Estimated average (m/s) excluding unreliable data
WTC1	Min	[0.25] (0.28)	[0.08] (0.13)	[0.18] (0.22)	[0.08] (0.13)	[0.08] (0.13)
	Max	[0.41] (0.41)	[0.31] (0.83)	[0.32] (0.39)	[0.41] (0.83)	[0.41] (0.83)
	Mean	[0.29] (0.33)	[0.19] (0.34)	[0.27] (0.32)	[0.24] (0.33)	[0.22] (0.34)
	Data points	[5] (5)	[10] (10)	[5] (5)	[20] (20)	[15] (15)
WTC2	Min	[0.2] (0.37)	[0.15] (0.17)	[0.16] (0.16)	[0.15] (0.16)	[0.15] (0.17)
	Max	[0.56] (0.71)	[0.26] (0.57)	[0.39] (0.47)	[0.56] (0.71)	[0.56] (0.71)
	Mean	[0.33] (0.49)	[0.21] (0.34)	[0.26] (0.3)	[0.27] (0.39)	[0.27] (0.42)
	Data points	[6] (7)	[6] (6)	[5] (5)	[17] (18)	[12] (13)

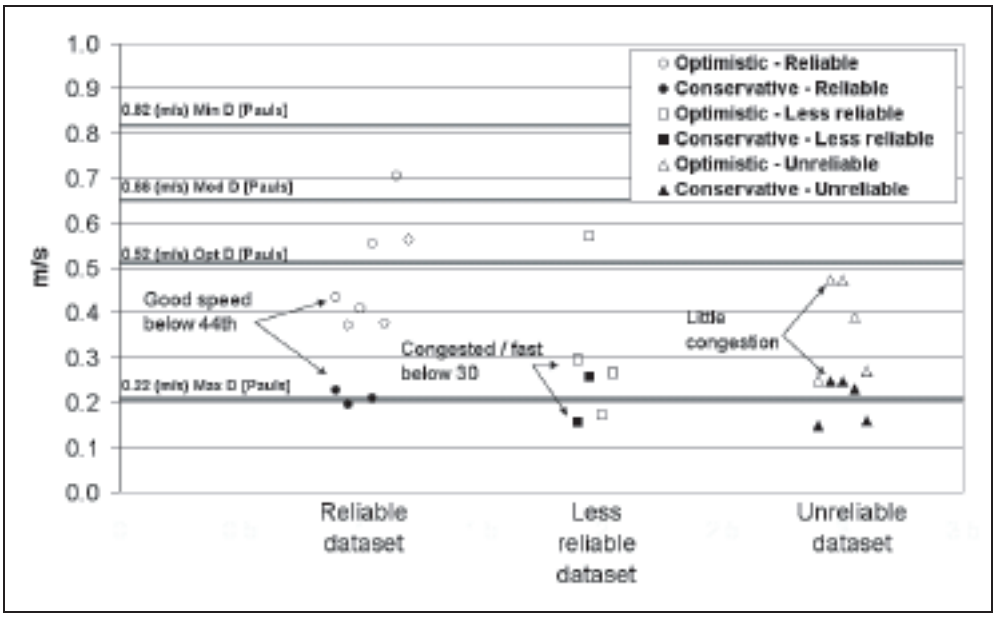
[ ] = conservative estimate, ( ) = optimistic estimate

The average estimated velocities in WTC2 are faster than those in WTC1. The mean average movement speed using only the reliable data for WTC2 was optimistically estimated as 0.49 m/s and conservatively at 0.33 m/s. The mean for WTC2 is broadly equivalent to Pauls movement rate in optimum conditions i.e. 0.52 m/s [6]. In WTC2 the range of velocities is broader then in WTC1 (0.2-0.7 m/s) with some occupants having relatively fast estimated velocities. These travel speeds are consistent with the implied conclusions that the available data for WTC2 is strongly focused on occupants who commenced their evacuation prior to T2, and hence prior to adverse physical conditions developing. Crowding of people on stairs would also have been reduced by the considerable number of people using elevators.

Figure 34: **Estimated stair descent speed (m/s) for WTC1 and WTC2**



WTC1



WTC2

7.6 CHANGING STAIRCASE DURING DESCENT

A number of occupants reported leaving the staircase in which they started their descent. This behaviour is considered significant since of the 177 occupant accounts within the database describing movement on stairs, 32% (55/177) reported leaving the stairs at some point during their descent. Here we attempt to determine why this action was taken.

Occupants were found to leave the stairs during their descent in both WTC1 and WTC2. Of the 55 occupants that reported this behaviour 47% (26/55) were within WTC1 and 53% (29/55) were within WTC2.

Of the occupants in WTC1 who reported using the stairs, 32% (26/81) reported leaving the stairs. Of these it was possible to determine a reason for this behaviour from 42% (11/26) of the cases. In total 20 distinct 'leave stair' events took place, with some occupants reporting leaving a particular staircase more than once (see Table 41). Examining the particular cases reported indicates that there was no single dominate reason for this behaviour but numerous different reasons. For example, 15% (3/20) of the occupants stated that they left the stairs to initiate a rescue of another occupant. A further 15% (3/20) stated that they were forced to leave the stairs as they met a locked door. Other less frequently reported reasons were: the stairwell ending (10% or 2/20), meeting congestion (10% or 2/20), darkness (10% or 2/20), etc.

Table 41: **Reasons for leaving the stairs from WTC1**

Reason	**#**
Rescue	3 [15%]
Met locked door	3 [15%]
Stairwell ended	2 [10%]
Congestion	2 [10%]
Darkness	2 [10%]
Attempted to use elevator	1 [5%]
Saw an elevator	1 [5%]
Smoke	1 [5%]
Firefighter	1 [5%]
To use telephone	1 [5%]
Evacuchair impeded	1 [5%]
To rest	1 [5%]
check relative	1 [5%]
No data	11

Table 42: **Reasons for leaving the stairs from WTC2**

Reason	**#**
Attempted to use an elevator	9 [38%]
At P/A announcement	2 [8%]
To investigate	2 [8%]
To rescue	2 [8%]
To use telephone	2 [8%]
Due to congestion	1 [4%]
Due to debris	1 [4%]
At sky lobby	1 [4%]
To rest	1 [4%]
Stairwell ended	1 [4%]
To get a drink	1 [4%]
Insufficient detail	3

Of the occupants in WTC2 who reported using the stairs, 30% (29/96) reported leaving the stairs. Of these it was possible to determine a reason for this behaviour from 90% (26/29) of the cases. In total 27 distinct 'leave stair' events took place, with some occupants reporting leaving a particular staircase more than once (see Table 42). Unlike in WTC1, the majority of these events were in order to attempt to use elevators, 38% (9/26). Of these four did so of their own volition and four were ordered to by emergency personnel. Other reasons provided for leaving the stairs were less frequent and more random. Reasons ranged from deciding to stop having heard the P/A announcement (8% or 2/26), stopping to rescue someone (8% or 2/26), to use a land line telephone (8% or 2/26), to investigate what was going on (8% or 2/26), etc (see Table 42). Some of the occupants stated that the stairs ended. These reasons suggest that occupants were prepared to break with stair evacuation for numerous reasons.

7.7 FIRE WARDENS

It was reported that each tenant in the towers was required to provide at least one fire warden. Tenants that occupied large areas of the building were required to provide one fire warden for every 697 m^2 of occupied space. In addition, the WTC had 25 fire safety directors who assisted in the coordination of fire safety activities in the buildings. Throughout the towers there were six satellite communication stations that were staffed by deputy fire safety directors. The fire safety directors also organised two yearly fire drills and trained the building fire wardens.

From accounts in the database, 94 occupants were identified as not being fire wardens, 7 were identified as being fire wardens while it is not clear if another 6 occupants were official fire wardens or not however, they appeared to undertake fire warden roles within their respective companies during the disaster. For the purpose of this analysis, these 6 individuals have been identified as unofficial fire wardens. A role could not be determined for 137 occupants within the database.

The data summarising fire warden actions is presented in Table 43 and Table 44. A coding scheme is used within the table that uniquely identifies each individual. The coding scheme is interpreted as follows, TOWER – FLOOR – STATUS – NUMBER, thus a fire warden who perished and was originally located on floor 84 of WTC1, would be tagged 1-84-F. Should more than one marshal be present in a particular group then they are assigned a unique number. Thus a second fire wardens that died who originally located on floor 84 of WTC1, would be tagged 1-84-F2. A survivor with similar details would be tagged as 1-84-S.

Of the official fire wardens 71% (6/7) perished in the disaster while 17% (1/6) of the unofficial fire wardens perished. The unofficial fire wardens mainly assumed responsibility for rounding occupants together and issuing instructions to evacuate in their office or on their office floor. Official fire wardens had more defined roles and were in contact with emergency personnel via walkie-talkies (4/7, 1-E-F, 2-84-F1, 2-84-F2 and 1-80-F) and/or phones (1/7 – 1-59-S).

None of the identified official or unofficial fire wardens reported evacuating without having undertaken their assigned (or assumed) responsibilities. There was no indication to suggest that people disobeyed the commands of the wardens. The wardens also appear to have been effective in getting people moving quickly.

Table 43: **Summary of OFFICIAL FIRE WARDENS and their activities**

Occupant code	Tower	Floor	Status	Undertook Fire Warden duties	Reported Activities	Did people follow instructions?	Self-evacuated without doing duties?
1-E-F	1	N/A	Perished	Yes	**Radioed for help**	N/A	NA (trapped in elevator)
2-84-S	2	84	Survived	Yes	Immediately grabbed equipment and yelled at people to leave. However when he/other people knew it was other tower hit, not his/ theirs, he stopped this and allowed people to stay.	Yes	No
2-84-F1	2	84	Perished	No data	Used **walkie-talkie** to say there was a lot of smoke, and helped carry a large woman downstairs.	No data	NA (trapped in elevator)
2-84-F2	2	84	Perished	Yes	Kept in contact by **walkie-talkie** with another warden who he went to back upstairs to help, and got people downstairs.	No data	No
1-59-S	1	59	Survived	Yes	Used **fire phone**	No data	No data
1-80-F	1	80	Perished	Yes	Evacuated people. Communicated with **walkie-talkie**.	No data	No
2-84-F	1	84	Perished	Yes	Got people to stairs. Many were afraid to leave.	No data	No

Table 44: **Summary of UNOFFICIAL FIRE WARDENS and their activities**

Occupant code	Tower	Floor	Status	Level of previous experience/ training	Reported Activities	Did people follow instructions?	Self-evacuated without doing duties?
2-100-S	2	100	Survived	Trained as a fire warden in previous job	Shouted calming words. Told people they were safe at that moment. Evacuated staff in his quarter to nearest stairs. Said don't use lift. Checked floor.	Yes	**No**
2-105-F	2	105	Perished	Fire Marshal	Told people 'explosion, leave'	Yes	**No**
2-X-S	2	?	Survived	Member of company fire team	Yelled 'time to go'	No data	No
2-1-S	2	1	Survived	Control room operator	Told people to use stairs not lifts	No data	No
2-80-S	2	80	Survived	No, but company had issued evacuation gear to all staff	Shouted 'it's a bomb, get out'	No data	NA
1-40-S	1	40	Survived	Had 'emergency situation training'	Shouted 'get out' as she got straight out herself	No data	No data

7.8 OCCUPANT PERFORMANCE ISSUES

A number of accounts highlighted personal performance issues that influenced the progress of individual evacuations. Listed in Table 45 are descriptions of physical performance and fatigue issues that were highlighted in occupants. These are examined in this section.

Table 45: **Summary of performance issues contained within the database during stair descent from both towers**

Type of occupant	Age	Tower	Init floor	Physical performance issue	Action taken
Female occupant	n/a	1	82	Tired legs	Took off shoes
Male Occupant	n/a	1	88	Tired legs	Assisted
Female occupant	n/a	1	91	Fell twice (wet stairs)	
Female occupant	n/a	1	91	Twisted Ankle	
Female occupant	n/a	1	81	Tired legs	
Female occupant	n/a	1		Tired legs	
Guide dog	n/a	1	78	Tired	
Male Occupant	n/a	1	71	People slipping	
Female occupant	n/a	1	71	Hyper Ventilating	Rested (5-10 minutes)
Firefighter	n/a	1	0	Tired	Rested
Firefighter	n/a	1	0	Tired	Rested
Firefighter	n/a	1	64	Tired	Rested
Female occupant	n/a	1	64	Hurting feet	Took off shoes
Female occupant	n/a	2	64	Was on crutches	Was helped by two occupants entire journey
Female occupant	n/a	2	100	Tired shoes hurt	Took off shoes
Female occupant	n/a	2	102	Thought shoes would hurt	Used lift instead of stairs
Male Occupant	n/a	2	70	slipped down the stairs	
Female occupant	n/a	2	92	had asthma so	Stopped every flight
Female occupant	n/a	2	93	Saw pregnant or slow moving	Moved slow
Female occupant	n/a	2	86	Unknown issue	Was helped down stairs entire journey
Male Occupant	n/a	2	64	Had asthma	Stopped frequently

7.8.1 Reports of slipping on the stairs

Three instances of people falling on stairs (3 accounts) are reported in the database. Two falls were due to an occupant slipping due to water whereas the one slipped due to building vibrations on impact.

7.8.2 Reports of people removing foot wear

Several accounts of fatigue reported by female occupants were due to the nature of the foot wear worn. Three accounts from women evacuating in high heels described them having to remove their shoes as they were causing their feet or legs to hurt. For example an occupant initially located on the 64th floor described removing her shoes at the 13th floor thus:

> *"Now they are on the 13th floor (Pasquale believes they were actually about nine floors higher, but Genelle remembers 13), and she stops to take her shoes off. She is wearing black leather heels today, and they hurt. It will be easier in bare feet. As Genelle is unstrapping them, she's holding Rosa's hand."*
>
> [Experience 673]

Similarly, another occupant from the 82nd floor described removing her shoes for similar reasons:

> *"By the time she reached the 30th Floor, Juliette was in trouble. Now her legs were cramping up. She took the shoes off, but that just made things worse. She thought about throwing the shoes away, but decided against it. Still clutching them and the handbag, she urged those behind her to go on ahead."*
>
> [Experience 2693]

The account of a male occupant suggests that many other women followed a similar course of action and completely discarded their shoes:

> *"On some landings there were women's shoes and clothing that people had discarded."*
>
> [Experience 1130]

Some women sought an alternative evacuation route so as to avoid the long descent in inappropriate foot wear:

> *"We got to the 78th floor and Judy said, "Let's see if the elevators are working." I'm thinking I shouldn't be taking an elevator, but I guess the thought of walking down 78th floors in my high heels was not exactly something I wanted to do. Judy was now a few people ahead of me. I followed her out onto 78th."*
>
> [Experience 3314]

These accounts suggest that it would be useful for high rise occupants to be instructed to remove inappropriate footwear in the event of evacuation. It would however be beneficial for occupants not to discard their shoes but to carry them in the event that potentially dangerous debris, such as glass, is present along their route.

7.8.3 Reports of people suffering asthma attacks

Two reported accounts were from asthma suffers. The asthma suffers described having to stop frequently. One account from an occupant initially located on the 64th floor described their asthma experience as follows:

> *"we began to smell jet fuel and a lot of it. I have asthma and it began to become a little difficult to breathe – 25 smelt lots of jet fuel – By the time I got down to the 20th floor I was having an asthma attack. A woman stopped to help me – by the 15th floor"*
>
> [Experience 605]

The only other account is from an occupant who started her evacuation from the 92nd floor. She described stopping more frequently:

> *"She had asthma so we had to stop at every flight because she couldn't breathe."*
>
> [Experience 3285]

7.8.4 Firefighter suffering fatigue

There were three accounts within the database of observations of firefighters who were suffering from fatigue and who stopped to rest.

7.8.5 Other issues

Several other factors were briefly reported by occupants, these included, observations of people using crutches, people twisting their ankles and the evacuation of a pregnant woman.

8. Concluding Comments

In reviewing the findings of this report, it must be remembered that the data on which the analysis is based was not collected in a scientific manner but from accounts in the public domain, primarily press accounts. As such it is difficult to generalise many of the findings. However, as much of the data was reported days after the incident, it provides a unique and insightful glimpse into the human response to such emergencies.

While the available information was far from ideal, the study has provided useful insight into the following issues: occupant response times in high rise buildings; nature of occupant pre-evacuation activities; the use of telephones and other electronic devices for communications by the occupants during the evacuation; retrieval of items by occupants prior to evacuation; occupant assessment of the incident; occupant travel speeds on stairs during the evacuation; occupant interaction with firefighters during the evacuation process; usage of elevators for evacuation; group formation, cohesion, leadership and behaviour; response of fire wardens and fatigue issues.

Several of the key findings of this research are:

- **OCCUPANT PRE-MOVEMENT TIMES:**
  Of the 115 people who provided information on which a pre-movement time (also referred to as response time) could be estimated, 60% responded within 5 minutes of the assault on WTC1 and some 13% took longer than an estimated 17 minutes to respond. Occupants in WTC2 responded quicker to the assault than occupants in WTC1 – the first tower to be attacked. This occurred in WTC2 despite instructions issued over the PA system in WTC2 instructing occupants that there was no need to evacuate WTC2. It is important to note that even under the extreme conditions of the terrorist attack on the WTC, occupant response times can be quite long. A lack of data prohibited a meaningful analysis of the speed of occupant response and proximity to the incident. While it is difficult to generalise due to the lack of data, the rapid response times of occupants in WTC2 relative to WTC1 may have contributed to the smaller death toll experienced in WTC2.

- **OCCUPANT PRE-EVACUATION ACTIONS:**
  (i) State of mind:
  On the whole the description of personal behaviours provided by the evacuees can be categorised as rationale. In describing their own actions and behaviours, none of the interviewees reported *Extreme Behaviour* or behaviour that fits the academic view of 'panic'. However, occupants did describe witnessing 5 events that may be interpreted as panic behaviour. This is a surprisingly small number of incidents given the gravity of the event.

  (ii) Nature of pre-evacuation actions:
  On average, occupants reported undertaking 3 distinct actions prior to evacuating. The dominant pre-evacuation action was to seek information. Some 72% of the reported pre-evacuation actions were concerned with communications or with physically attempting to obtain situational information. In attempting to collect information, occupants attempted to make use of television, radio, email and telephones as well as simply moving to widows. Clearly the occupants of both towers were operating in an information deprived state. This is considered significant as the requirement for this action could be removed if occupants could be provided with appropriate information. Reducing the need for gathering information may assist in reducing response times and overall evacuation times. Improved communication systems and procedures for disseminating information will allow occupants to more rapidly make appropriate evacuation decisions.

  (iii) Knowledge of the event:
  Of the survivors who reported their perception of the event during the pre-evacuation phase, some 41% (20/49) of survivors in WTC1 and some 36% (10/28) of the survivors in WTC2 reported that they thought the incident was the result of an aircraft impact. Thus in both towers, while a large number of people suspected that the incident was aircraft related, the majority of the survivors *did not* believe that the assault was the result of an aircraft impact. This further supports the observation that all survivors did not have accurate information regarding the event.

(iv) Usage of telephones:
Of the people who provided information relating to their actions, 20% stated that they made telephone calls. A significant number of these calls (75%) where not to emergency services or colleagues but to family members and the majority of the calls made by survivors were in the *pre-evacuation* phase. Surprisingly, most of these were to assure family members that they were OK – not to secure further information or advice. The propensity of occupants to make telephone calls is considered potentially significant as it is an action that slows occupant evacuation, especially as the majority of calls involved providing rather than receiving information. While it may be considered natural to inform 'loved ones' of ones safety, undertaking this action is ill advised while still exposed to potential danger. It is suggested that as part of regular evacuation training and safety briefings, participants should be advised not to make personal calls until they have safely exited the building as this can prolong evacuation thereby jeopardising their chance of survival.

(v) Collecting Items:
Some 26.5% of the surviving population within the survey (94 people) reported collecting personal items (79% of collected items) or work items prior to evacuating. Most occupants that reported collecting items described collecting items from their desk whilst at their desk or within the immediate local vicinity. However, 6.4% of the surviving population explicitly stated that they had to return to their desk or office from a distant location. Whilst in some instances this action can be accomplished quickly in other instances the action can take considerable time and involve significant additional travel – perhaps in the opposite direction to evacuation. As such the occurrence of this behaviour should be viewed as serious and potentially hazardous. It is suggested that, as part of regular evacuation training and safety briefings, participants should be advised not to attempt to retrieve personal or work items but to evacuate as soon as possible or as soon as instructed.

- **EVACUATION PHASE**

(i) Flow conditions within the towers:
What little data that is available suggests that the stairs were packed and moving slowly below the 44th floor in WTC1 and slow between the 44th and 78th floors. In WTC2 the data suggests that there were lots of people at the sky lobby on the 78th floor. The stairs in WTC2 may have been initially packed and slow moving between the 78th and 44th sky lobbies but later may have become less packed. The stairs below the 44th sky lobby were not densely packed and were fast moving. Most flows were described as orderly even those that were slow and heavily congested. Unfortunately, due to deficiencies in the available data, such as clear indications of time frames, location on stairs and which staircase was used, it is not possible to provide a more detailed analysis.

(ii) Obstructions to flow:
A number of accounts from WTC1 highlight situations in which non-injured occupants progressed down the stairs in single file, allowing injured occupants to be assisted down the unobstructed lane. This altruistic behaviour supports the view that the evacuation was calm and non-competitive in nature. A few accounts also describe the passage of firefighters up the stairs. The accounts that are available suggest that the firefighters may have hindered the passage of some occupants in WTC1, but it is not clear if this had a significant impact on overall

evacuation times. The available accounts describe firefighters as constricting the effective width whilst moving up the stairs and while recovering from fatigue. It is suggested that as part of firefighter training, firefighters be instructed that during the ascent of tall buildings, prior to taking a rest period, they should move off the stairs, if considered safe, in order not to obstruct the flow of evacuating occupants. Several accounts describe the flow as coming to a complete halt. All of these reports were taken from floors below the 44th floor. These events may have contributed to the poor flow conditions reported in these areas of WTC1. Water was also reported by occupants below the 44th floor of WTC1. The presence of water would have served to slow occupant evacuation as movement rates would have been severely hindered by the presence of water and several occupants reported slipping in the treacherous conditions. Reports of the injured and firefighters impacting the flow conditions in WTC2 were far fewer.

(iii) Usage of elevators as a means of evacuation in WTC2:
There are 95 occupant accounts reporting evacuation phase experiences in WTC2. Of these, 28.4% (26 accounts) report elevator evacuation usage prior to the attack on WTC2 and represent some 38 elevator embarkations. While this represents a significant usage of elevators, it is not possible to conclude from this information alone that the elevators played a *significant positive role* in the evacuation success of WTC2. However, it would appear reasonable to assume that the heavy reported usage of elevators in WTC2 prior to the assault on that building could have made two positive contributions to the evacuation. Firstly, heavy usage of elevators would have assisted clearing large numbers of people from the upper floors of WTC2 prior to the assault on that building. Secondly, the usage of elevators by significant numbers of people would have eased the congestion on the stairs in WTC2, making movement on the stairs more efficient. However, a significant number of people also delayed their evacuation – some with fatal consequences – waiting for elevators. Clearly, more research is required in exploring how elevators can be effectively used in large scale building evacuations.

(iv) Group Behaviour:
Of the WTC1 accounts that allowed an assessment of group formation to be made, 90% (62/69) suggested the formation of some type of group during the pre-evacuation phase. In WTC2 a similar trend was noted with 88% (69/78) of the population describing forming groups. Only 10% (WTC1) and 12% (WTC2) of occupants that made an evacuation reported evacuating by themselves. In WTC2, 90% (19/21) of the groups that formed were small (less than 5 people) and very few large groups formed. Indeed, 62% (13/21) of the groups involved only two people. In contrast in WTC1 we find that group sizes tended to be more evenly distributed between small (less than 5), medium (6 to 10) and large (greater than 10).

Of the groups in WTC1 and WTC2, 80% (12/15) and 71% (20/28) respectively, consisted of employees from the same office and 13% (2/15) and 18% (5/28) of groups consisted of a mixture of office and adjacent office employees. This information combined with the group size information may suggest that in WTC2 evacuation decisions were taken on a local/personal basis perhaps involving small localised groups of colleagues. In contrast, in WTC1 larger groups tended to form and this may have been based on collective decisions centralised on an office basis.

Group size was found to be dynamic in nature, expanding and contracting during the evacuation. When groups contracted in size, the predominant reason for this was the deliberate action of a group member, not adverse environmental or situational conditions forcing a group to split. In WTC1 a significant number of the groups that formed split during the (6/10) descent, primarily for deliberate and individual reasons. In WTC2, a smaller proportion of groups split during the descent (8/20). Here again, the predominant reasons for breaking the group were based around deliberate actions by groups members.

The vast majority of groups for which there is sufficient information were led by their line manager during pre-evacuation. Clearly, organisational managers and authority figures are likely to be figures of authority in emergency situations and so they should be well versed in emergency procedures. If possible, line managers should receive fire warden training. However, due to the nature of their organisational roles, line managers and authority figures are likely to spend a considerable amount of their time away from the office. Thus, they should be considered an additional resource rather than the sole fire trained asset.

The observations relating to group behaviour are considered significant. If substantiated by more detailed studies into the WTC disaster, they should have a profound impact on evacuation planning and modelling as groups can exert a significant influence on a range of evacuation parameters such as *Response times, Travel speeds, Way Finding and overall evacuation efficiency and time.* Furthermore, due to its nature, the type of group behaviour noted in this study is unlikely to occur in evacuation drills or exercises. The study of real incidents such as the WTC disaster provides the opportunity to study group behaviour that is extremely difficult, if not impossible to reliably reproduce in 'laboratory' or controlled experiments.

(v) Stair Travel Speeds:
Stair travel speeds for occupants in WTC2 were faster on average than those for WTC1. Mean stair descent rates of between 1.8 floors/min and 2.1 floors/min were estimated for WTC1. In contrast, the data from WTC2 suggests a mean descent rate of between 2.1 floors/min and 3.0 floors/min. Analysis of this data suggests that in WTC1 optimistically, mean movement speeds could have been as low as 0.33 m/s with a spread in travel speeds of 0.25-0.41 m/s. In WTC2, the mean average movement speed using only the reliable data for WTC2 was optimistically estimated as 0.49 m/s with a spread in travel speeds of 0.2-0.7 m/s. These travel speeds are consistent with the implied conclusions that the available data for WTC2 is strongly focused on occupants who commenced their evacuation prior to the assault on WTC2, and hence prior to adverse physical conditions developing. Crowding of people on stairs would also have been reduced by the considerable number of people using elevators.

(vi) Fire Wardens:
Of the official fire wardens 71% (6/7) perished in the disaster while 17% (1/6) of the unofficial fire wardens perished. The unofficial fire wardens mainly assumed responsibility for rounding occupants together and issuing instructions to evacuate their office or office floor. None of the identified official or unofficial fire wardens reported evacuating without having undertaken their assigned (or assumed) responsibilities. There was no indication to suggest that people disobeyed the commands of the wardens.

(vii) Fatigue:
Several accounts of fatigue reported by female occupants were due to the nature of the foot wear worn. Discarded female footwear was also reported on the stairs. These accounts suggest that it would be useful for high rise occupants to be instructed to remove inappropriate footwear in the event of evacuation. It would however be beneficial for occupants not to discard their shoes but to carry them in the event that potentially dangerous debris, such as glass, is present along their route.

This study has provided insight into the response of people subjected to extreme emergency conditions in high rise buildings. The information is useful in its own right in understanding how the evacuation of the World Trade Centre Towers evolved on 11 September 2001. More significantly, the insight gained will be useful in shaping our building codes and devising emergency procedures for evacuation. Furthermore, the information collected will be invaluable in assisting the development of behaviour models that are key components of evacuation models used in performance based building design and in providing data for model scenario specification.

However, it should be noted that the data on which this study is based is far from ideal. Reliance on published press accounts and accounts that have appeared in the public domain has meant that:

- Survey participants were not scientifically selected, potentially producing a biased sample. The information that was available meant that the population sample was focused on occupants from the upper portions of both towers.
- Due to the amount of published information, the sample population size was small.
- Survey participants provided incomplete information, either because the journalist did not ask the appropriate questions or if the information was collected, the journalist did not believe the information was sufficiently news worthy and so was not published. Examples include:
  - From the information that was available, it was not possible to determine which staircase people used.
  - It was not possible to determine when or where certain reported experiences occurred.
  - Many people within the sample did not provide response time information.
  - Not everyone who encountered firefighters necessarily described the incident.
  - Insufficient information relating to usage of elevators.
- Inability to pursue specific research themes such as observations of panic, group formation and behaviour, role of fire wardens, usage of elevators.

These limitations will be addressed in a much larger study into the evacuation of the WTC. The project, called HEED – High-rise Evacuation Evaluation Database – funded by the UK EPSRC (project GR/S74201/01) and involving the Universities of Greenwich, Ulster and Liverpool, aims to interview 2000 survivors of the WTC twin towers evacuation. The data collected and analysed in the BDAG study will be used as the starting point for HEED.

References

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3 Galea E.R., Passenger Behaviour in Emergency Situations, Chapter 10 in edited book, Passenger Behaviour, editor Robert Bor, Ashgate 2003, pp128-182.

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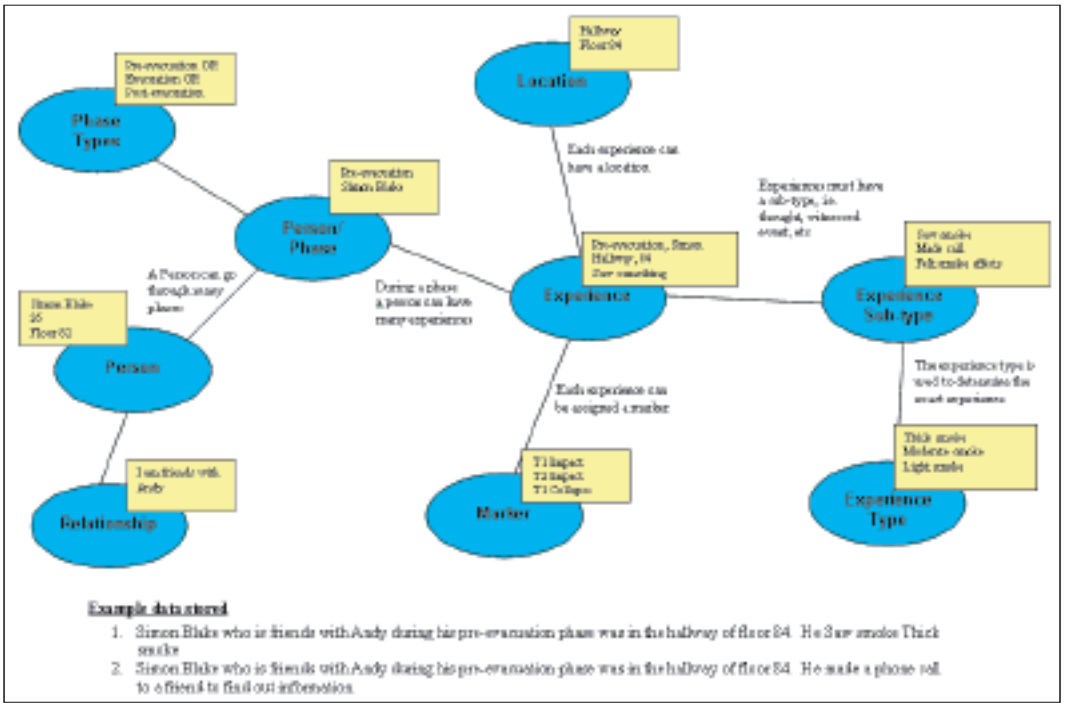
ANNEX 1:

9. The database structure

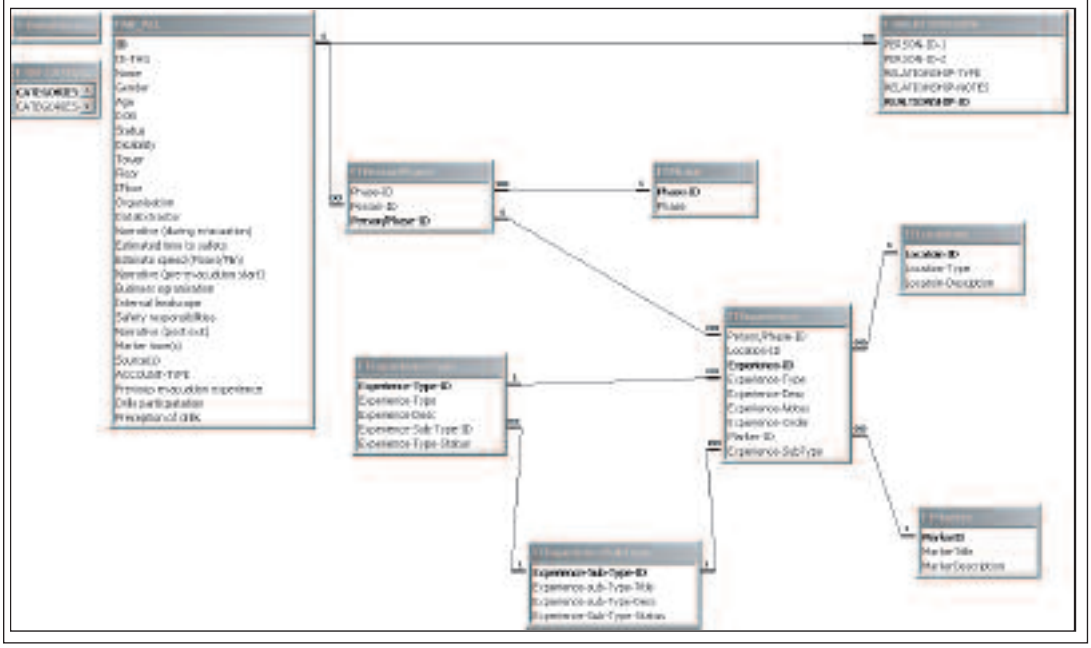
A Microsoft Access database served as the repository for the information that was collected. The database represents a flexible qualitative research tool that allows the operator to categorise occupant experience during the data input process. Traditionally qualitative analysis tools allow users to categorise details from textual accounts during the input process. A feature of the database is that it is not only able to store experiences but also the location of the experience and a time reference of the experience. It is in this context that the tool developed for this study differs from typical qualitative research software. The developed database is however ideally suited for evacuation analysis.

Figure 35: **Entity relational diagram for the database schema**



The rationale for the database was that **all information was cantered around an occupant experience**. Branching from the occupant experience (Marked Experience in Figure 35) a specific location, a time reference, the evacuation phase and details of the occupant that described the experience. These components each contained data elements that were used to store information relating to the occupant and their experiences Each of the core components that comprise the database are summarised in the remainder of this annex.

Figure 36: **Design database schema in MS Access**



9.1 THE 'PERSONAL DATA' DATABASE COMPONENT

The personal data table contains singular personal information that may be unique to each person. Demographic data such as Name, Gender, Age, DOB or pre-existing disabilities are recorded in this section of the database. Also the floor that they occupied at the start of the evacuation, the 'normal' floor that they work on, the organisation that they work, their job title and the internal landscape of their offices. This was followed by their safety responsibilities, previous evacuation experience, whether they have participated in any evacuation drills and if so their perception of them.

In addition some simple details about an occupant's evacuation, such as whether they evacuated in a group of on their own and/or whether they sustained injuries. In addition a feature of this evacuation was that accounts from dead occupants were sometimes available. Typically these accounts constituted phone calls to friends, relatives or reporters. It was therefore necessary to record the final status of the occupant (i.e. FATALITY or SURVIVOR). Finally for audit purposes, the name of the analyst entering the data is included, as are the complete textual data source, references to sources and the type of account upon which the entries were made (i.e. FULL INTERVIEW, INFERRED ACCOUNT, etc.).

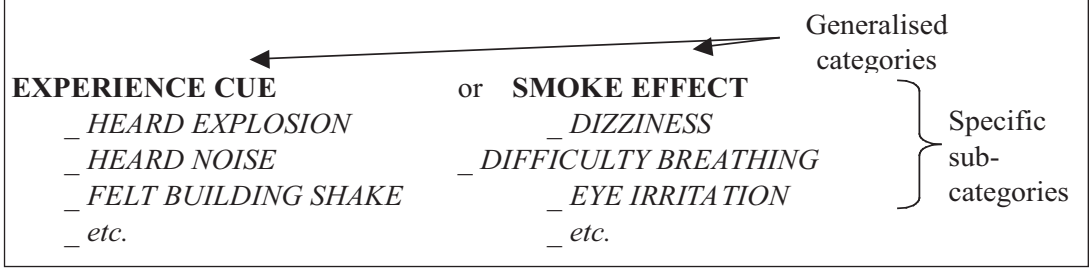
9.2 THE 'RELATIONSHIP' DATABASE COMPONENT

This table was used to define the relationships between occupants (i.e. FRIEND, COLLEAGUE, etc.). The type of relationship, a brief description usually a quote from their transcript and the occupants involved were also recorded.

9.3 THE 'EXPERIENCES CATEGORIES' DATABASE COMPONENTS (EXPERIENCE TYPE/EXPERIENCE SUB-TYPE)

The analysis phase of this project required the human experience data to be categorised in some way. A master/child or main category/sub-category approach was deemed most suitable given the quality of the data. This scheme involved grouping specific experiences, such as experienced DIZZINESS or DIFFICULTY BREATHING into more general categories such as SMOKE EFFECTS (see Figure 37). In this way specific details of each experience could be recorded in addition to a more generalised description of the experience. The advantage of this approach was the more general aspects could be analysed where specific information was limited and conversely a more fine analysis of sub-categories was also possible where the database contained sufficiently detailed information.

Figure 37: **The experience categorisation scheme**



9.4 THE 'EXPERIENCE' DATABASE COMPONENT

The main experience component stores all of the information about a particular experience for a person. Within the database an experience entry would comprise of a:

- general category for the experience,
- specific category for the experience,
- evacuation phase for the experience,
- order that the experience took place relative to other experiences,
- a marker reference,
- the location of the experience, and
- a brief description of the experience.

The general category of the experiences was selected from pre-defined categories or created by the user during the data entry process. A general category for the experience was first required, for example "EXPERIENCED CUE" or "SMOKE EFFECT", etc.). Having chosen or created a general category for the experience a more specific sub-type category for the experience was either selected or created. The user could then type in the actual textual description of the experience from the account.

Having defined the type of experience it was then tied to a particular phase of the occupant's evacuation (i.e. PRE-EVACUATION, EVACUATION and POST-EVACUATION) assigned a location in the building that it took place, (i.e. WTCl, Floor 87, Office space) and a time marker. Locations were either selected from those already entered or the user had the option of creating a new one.

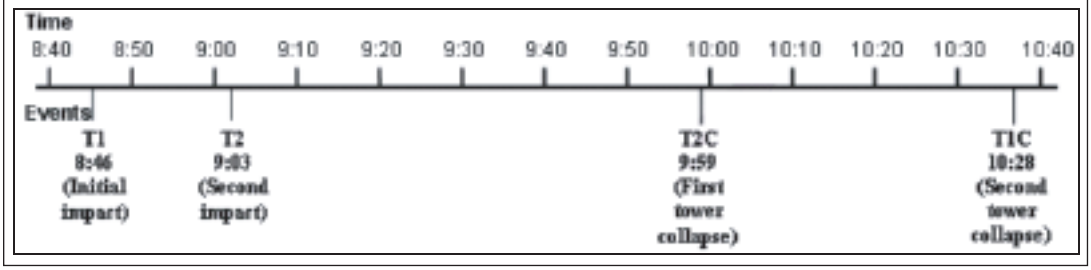
Finally, each experience was assigned a number denoting the temporal order of the experience relative to others within the account (i.e. 1st experience, 2nd experience, nth experience etc.). Where experiences represented the same experience order, i.e. in a fire *felt heat, coughed, felt dizzy*, they were all tagged with the same experience order. Whilst not providing specific times for experience this technique would allow the order of events to be analysed.

9.5 A METHOD OF CAPTURING TEMPORAL INFORMATION

A method was also required for determining some temporal information for each. Within the WTC disaster there were four key event markers that were experienced to some degree by most occupants. As shown in Figure 38 they are the:

1. Initial impact into T1 at 8:46am, 2,
2. Second impact into T2 at 9:03am,
3. Collapse of WTC2 at 9:59am,
4. Collapse of WTC1 at 10:28am.

Figure 38: **Timeline of key event markers in the WTC evacuations**



Most occupants had some indication that these events took place. Occupants felt impact effects. Some reported feeling the building sway, shudder or described hearing a large explosion. For example,

> *"It was at that moment that United Airlines Flight 175 hit the South Tower. They heard the dull sound of impact but couldn't see anything. Again the building swayed, but much less than the first time. The radio announcer sounded desperate. "We're being attacked!" he shouted."*
>
> [Experience 2889]

In some cases occupants were able to see the impacts directly. Regardless of the method most occupants were able to report what they were doing at the time of the impacts. Similarly the collapse of the towers was characterised by a loud noise and/or lighting failure and/or the sudden loss of vision, for example:

> *"Juliette was pitched off her feet, one of her escorts landing on top of her. There was a deafening roar, like an ungodly waterfall. The entire building felt like it was going to shake off its foundations. The lights went dead and the concourse went pitch black."*
>
> [Experience 2724]

Furthermore many occupants were able to report their location and actions at the point of the WTC2 collapse. Some occupants reported the WTC1 collapse from outside of the building:

> *"From there, the [my] people slowly descended out of the South Tower. They escaped the building about 12 to 15 minutes before it collapsed."*
>
> [Experience 847]

Although in some case occupants were still inside the building when it collapsed:

> *"Something big comes through one wall at Genelle and Rosa and pushes them back. They fall, but Rosa recovers her footing. Genelle stays on the floor and starts to crawl downward. All this happens quickly, but there is time for them to separate. Rosa moves as if she is headed back up the stairs. Genelle is jostled like a pinball and struck by debris from everywhere. As the great noise begins to subside, she is lying on her right side, and her right leg is pinned hard. Her head is now caught between something, the floor maybe?, and some concrete. Finally, it's all quiet, and it's dark, but somehow she is here. She is alive."*
>
> [Experience 679 and 2971]

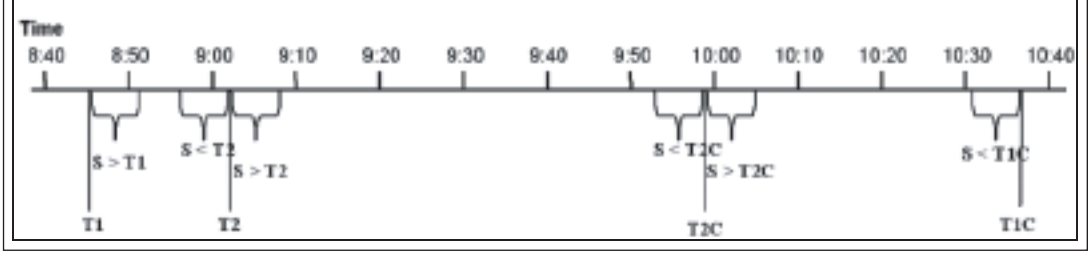
For most occupants it was possible to attribute their location and actions at 8:46, 9:03, 9:59 and 10:28am. This was very important as it enabled a time reference to be inserted into their evacuation accounts that could be used to determine:

a) How long it took to perform certain phases of the evacuation (i.e. response times)
b) How long it took to perform certain actions
c) And also travel speeds through various portions of the building.

Using these time makers it was also possible to determine those experiences that occurred shortly before the key event markers. For the purpose of this work we defined shortly before/after as being within 5 minutes of the key marker. This yielded the following additional 6 markers (see Figure 39):

S > T1 = Shortly after the T1 impact (i.e. between 8:46 and 8:51)
S < T2 = Shortly before the T2 impact (i.e. between 8:58 and 9:03)
S> T2 = Shortly after the T2 impact (i.e. between 9:03 and 9:08)
S < T2C = Shortly before the T2C (i.e. between 9:53 and 9:59)
S > T2C = Shortly after the T2C (i.e. between 9:59 and 10:04)
S < T1C = Shortly before the T1C (i.e. between 10:23 and 10:28)

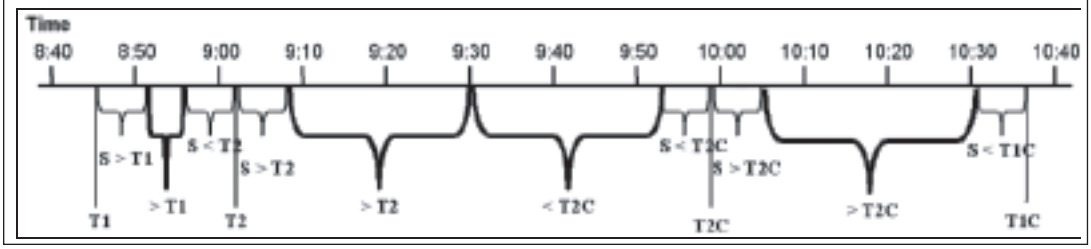
Figure 39: **Timeline and ADDITIONAL event markers used**



This left time periods between 8:51 and 8:58, 9:08 and 9:53 and 10:04 and 10:23 as unaccounted time markers (see Figure 40). These were used as additional categories within the database. However, to enable a more accurate estimate of timings the largest of these categories (i.e. 9:08 and 9:53) was divided into two time periods. In essence a judgement was made, "did the experience occur closer to T2 impact or T2C?" The following four additional time markers were used within the database:

> T1 = Some time between S>T1 and S<T2 (i.e. 8:51 to 8:58)
> T2 = Some time between S>T2 and <T2C (9:08 to 9:31)
< T2C = Some time between >T2 and S<T2C (9:31 to 10:04)
> T2C = Some time between S>T2C and S<T1C (10:04 to 10:23)

Figure 40: **Timeline and ADDITIONAL event markers used**



The final list of markers that were used within the database and their related time periods are as follows:

T1 = WTC1 impact (8:46),
T2 = WTC2 impact (9:03),
T2C = WTC2 collapse (9:59),
T1C = WTC1 collapse (10:37),
S > T1 = Shortly after the T1 impact (i.e. between 8:46 and 8:51),
S < T2 = Shortly before the T2 impact (i.e. between 8:58 and 9:03),
S> T2 = Shortly after the T2 impact (i.e. between 9:03 and 9:08),
S < T2C = Shortly before the T2C (i.e. between 9:53 and 9:59),
S > T2C = Shortly after the T2C (i.e. between 9:59 and 10:04),
S < T1C = Shortly before the T1C (i.e. between 10:23 and 10:28),
> T1 = Some time between S>T1 and S<T2 (i.e. 8:51 to 8:58),
> T2 = Some time between S>T2 and <T2C (9:08 to 9:31),
< T2C = Some time between >T2 and S<T2C (9:31 to 10:04),
> T2C = Some time between S>T2C and S<T1C (10:04 to 10:23).

9.6 THE 'PHASE' DATABASE COMPONENT

This database component was used to define different phases of the overall evacuation. Only three phases were defined within this study, Pre-evacuation, Evacuation and Post-Evacuation. These are defined below:

Pre-evacuation This phase was used to tag occupant experiences that occurred prior to the physical act of evacuating. In this work this includes all activities undertaken by occupants prior to taking their first step to evacuate from their current floor. Pre-evacuation activities include occupant actions such as turning back to collect to collect belongings prior to reaching a staircase. Similarly, occupant actions involving moving to a different room to seek shelter are classed as pre-evacuation activities. The distinction made is subjective but allows the differentiation of actions and experiences that occurred during descent or in some cases ascent and activities that occurred more locally to occupants' work places.

Evacuation This tag was applied to occupant experiences during occupant descent and evacuation. In this analysis the evacuation phase was defined as the period post pre-evacuation during which the occupant actively attempted to evacuate. Once begun an occupant was deemed to be in evacuation mode until they either perished or exited the building. Experiences from evacuating occupants who cease movement and seek shelter are classed as evacuation actions.

Post-evacuation This tag was applied to occupant experiences that occurred once the occupant had left the building.

9.7 THE 'PERSON/PHASE' DATABASE COMPONENT

This database component is an intermediary table required in a relational database that relates a particular occupant to a particular phase.

9.8 THE 'MARKER' DATABASE COMPONENT

This component was used to define time markers within the database. Only defined time markers could be assigned to an occupant experience. Users could however define time markers during the data input process. A more detailed description of time markers was given in Section 9.5.

9.9 THE DATA INPUT PROCESS

The analyst entering the data would the account from start to finish as many times as necessary to familiarise themselves with and understand the events that were being described. The analyst would then begin to enter the experiences in the order described in the account.

9.10 THE DATABASE CONTENTS

Reports were gathered from the literature published in the open domain. Material sources ranged from printed newspaper reports collected at the time of the disaster, online newspaper reports, web sites of survivor accounts and books about the disaster itself.

In total 260 occupants were identified from accounts. Of these 120 occupants were located in WTC1 and 119 in WTC2 (see Table 46). Unfortunately it was not possible to identify a tower for 21 of the occupants. This was due to the relatively short accounts supplying insufficient detail. All of the accounts in which a tower could not be identified fell into the 'poor' quality category.

In total the database was populated using 125 occupants whose details were rated as being of 'poor' detail, 75 of 'average' detail and 35 of 'exceptional' detail (see Table 47).

Table 46: **Summary of accounts and experiences contained within the database**

WTC tower	Accounts	Experiences
Unknown	21	11
1	120	1,869
2	119	1,411
Total	260	3,291

Table 47: **Summary of accounts by quality**

	Tower	
	1	**2**
Poor quality	55	74
Average quality	45	30
Exceptional quality	20	15
Total	120	119

The database records each experience cited by each occupant, in total some 1869 distinct experiences were recorded from reports of occupants in WTC1 and a further 1,411 distinct experiences were recorded from reports of occupants in WTC2. The database therefore contained 3280 experiences. A further 11 experiences were recorded from occupants whose tower could not be determined – these originated from 21 occupants.

The reports mainly came from occupants that begun their evacuation in the upper floors of either tower. Within the database, 73 (61%) and 91 (76%) of the occupants from WTC1 and WTC2 respectively were initially located on or above the 78th sky lobby (see Figure 41). These represent some 59% and 79% (1,106 and 1,109 experiences respectively) of accounts contained within the database. It is likely that this bias originates from the medias natural desire to focus on accounts that described the most extreme conditions during the disaster.

Figure 41: **Distribution of experiences and accounts throughout each of the towers**

Floors 110-78

	Accounts		Experiences	
floor	T1	T2	T1	T2
110	1		0	
109				
108				
107	1		9	
106	11		4	
105	4	4	49	13
104	5	2	22	22
103		7		95
102		4		39
101		1		1
100		8		193
99		1		1
98	1	4	45	22
97	1	4	1	35
96				
95	1	2	3	48
94				
93		5		67
92	2	5	17	46
91	7	4	134	64
90		4		26
89	7	4	169	21
88	1	1	18	10
87	11	7	267	29
86	3	6	57	24
85	2		47	
84		12		198
83	1		35	
82	3		69	
81	2	1	57	76
80	3	4	42	44
79		1		35
78	6		61	

Floors 78-44

	Accounts		Experiences	
floor	T1	T2	T1	T2
77		1		8
76				
75				
74	1		25	
73	1	1	6	3
72	1	1	7	25
71	3	1	60	7
70	2	2	82	24
69	2		48	
68	1		1	
67	1		19	
66				
65	1		19	
64	4	3	122	50
63				
62				
61	3	3	8	42
60		1		1
59	1		9	
58		1		47
57	1		9	
56				
55		1		24
54				
53				
52	1		14	
51				
50				
49				
48				
47	2		25	
46				
45	5		100	
44		1		3

Floors 44-1

	Accounts		Experiences	
floor	T1	T2	T1	T2
43	1		12	
42				
41				
40	2		52	
39				
38	1		17	
37				
36				
35				
34	1		12	
33				
32				
31				
30				
29				
28				
27				
26				
25				
24				
23				
22				
21				
20				
19				
18				
17				
16				
15				
14				
13				
12				
11				
10	1		22	
9				
8	1		13	
7				
6				
5				
4				
3				
2				
1		2		13

10. Annex 2

10.1 DESCRIPTION OF DATABASE FIELDS USED IN THE OCCUPANT-DETAIL TABLE

ID	The primary key field for the occupant detail table
In Alleviator	Did the occupant begin their evacuation in an elevator
PRE-EVAC-GROUP	What group did the occupant belong to: Arbitrary but unique designation
GROUP-ID	What group did the occupant belong to during EVACUATION: Uses same as PRE-EVACUATION if possible otherwise arbitrary but unique designation
ID-TAG	There tag string TOWER-FLOOR-OCCUPANT
ABSFLOOR	The floor the occupant was on when they began their report
Impact Zone	The impact zone that the occupant was positioned in at the start of their report.
Tower	The tower that the occupant was located in at the start of their report.
Name	The name of the occupant
PCODE	
Gender	Their gender
Age	Their age
DOB	Their DOB
Status	Their status: SURVIVOR/FATALITY
Disability	Details of any disability they may have had.
Floor	The floor that they usual work on
IFloor	Floor coding used in the analysis and report.
Floor Group	Floor coding used in the analysis and report.
FloorGroup2	Floor coding used in the analysis and report.
Organisation	The organisation that they may work for.
Data Extractor	The name of the researcher who entered the data into the database.
Narrative (during evacuation)	The complete narrative of their EVACUATION
Estimated time to safety	How long we estimate that it took them to reach a place of safety
Estimate speed (Floors/Min)	Their estimate floors/minute
Narrative (pre-evacuation start)	The complete narrative of their PRE-EVACUATION

Business organisation	
Internal landscape	The internal landscape of their office. Desks, open plan, destruction, etc.
Safety responsibilities	Whether the occupant had any pre-defined safety responsibilities.
Narrative (post exit)	The complete narrative POST-EVACUATION
Marker time(s)	
Source(s)	The information sources from which the report(s) came.
ACCOUNT-TYPE	The type of account. News paper, interview, web based, police report
Previous evacuation experience	Whether they had any previous evacuation experience.
Drills participation	Whether the occupant participated in any drills prior to the events of 9/11
Perception of drills	What was the occupants perception of the drills
FULL TRANSCRIPT	The full transcript of their reports. Where available from sources that can be cut and paste.
INJURIES	Whether the occupant had sustained any injuries during the evacuation.
EVACUATED AS GROUP	Whether the occupant evacuated as a group. Boolean Yes/No.
ACCOUNT_TYPE-2	
TOTAL_EXPS	The total number of occupant experiences
PRE_EXPS	The total number of PRE-EVACUATION occupant experiences
EVAC_EXPS	The total number of EVACUATION occupant experience
POST_EXPS	The total number of POST-EVACUATION occupant experience
PRE_ACT	The total number of PRE-EVACUATION occupant actions
EVAC_ACT	The total number of EVACUATION occupant actions
POST_ACT	The total number of POST-EVACUATION occupant actions

10.2 DESCRIPTION OF DATABASE FIELDS USED IN THE PERSON-PHASE TABLE

Phase-ID	the foreign key from the PHASE table
Person-ID	The foreign key from the OCCUPANT-DETAIL table
Person/Phase-ID	The primary key for this table.

10.3 DESCRIPTION OF DATABASE FIELDS USED IN THE PHASE TABLE

Phase-ID	The primary key for this table.
Phase	The name of the phase: PRE-EVACUATION, EVACUATION, POST-EVACUATION. In subsequent version of the database: OPERATIONAL was added.

10.4 DESCRIPTION OF THE DATABASE FIELDS USED IN THE MARKERS TABLE

MarkerID	The primary key for the MARKER table.
MarkerTitle	The name of the marker, i.e. T1, >T1, 9:08, etc.
Marker Description	The designation of the marker in terms of: Slow/Moderate/Rapid
EventOrder	The temporal order of the marker relative to other markers in the table.

10.5 DESCRIPTION OF THE DATABASE FIELDS USED IN THE LOCATION TABLE

Location-ID	The primary key for the LOCATION table.
Location-Type	The name of the location, i.e. 92, halls = 92nd floor hallways, 78, stairs = on the stairs at floor 78.
Location-Description	A description of the location

10.6 DESCRIPTION OF THE DATABASE FIELDS USED IN THE EXPERIENCE SUB TYPE TABLE

Experience-Sub-Type-ID	The primary key for the EXPERIENCE SUB TYPE table
Experience-sub-Type-Title	The name of the experience type, i.e. SMOKE EFFECT, OBSERVATION (EXTREME BEHAVIOUR), ACTION (MAKE CALL), etc
Experience-sub-Type-Desc	A brief description of the meaning of the sub experience type.
Experience-Sub-Type-Status	Whether the experience is currently in use within the database or has been marked as not used.

10.7 DESCRIPTION OF THE DATABASE FIELDS USED IN THE EXPERIENCE TYPE TABLE

Experience-Type-ID	The primary key for the EXPERIENCE TYPE table.
Experience-Type	The name of the experience type, i.e. DIFFICULTY BREATHING, SAW RUNNING, MADE PHONE CALL, etc.
Experience-Desc	A brief description of the meaning of the experience type.
Experience-Sub-Type-ID	The foreign key from the sub-type table, i.e. the master category for the experience.
Experience-Type-Status	Whether the experience is currently in use within the database or has been marked as not used.

10.8 DESCRIPTION OF THE DATABASE FIELDS USED IN THE EXPERIENCE TABLE

Person/Phase-ID	A foreign key from the PERSON PHASE table
Location-ID	A foreign key from the LOCATION table
Experience-ID	The primary key for the EXPERIENCE table
Experience-Type	A foreign key from the EXPERIENCE TYPE table
Experience-Desc	Whether the experience is currently in use within the database or has been marked as not used.
Experience-Notes	A brief description of the meaning of the experience type.
Experience-Order	The order of the experience as reported in the occupant account.
Marker-ID	A foreign key from the MARKER table
Experience-SubType	A foreign key from the EXPERIENCE SUB TYPE table
DateCreated	The date that the experience was entered.
Normalised-Order	The normalised order of their experience, i.e. order has a range 0-1
Normalised_Pre	The normalised order of their PRE-EVACUATION experiences, i.e. PRE-EVACUATION orders have a range 0-1
Normalised_Post	The normalised order of their EVACUATION experiences, i.e. EVACUATION orders have a range 0-1
Normalised_Evac	The normalised order of their POST-EVACUATION experiences, i.e. POST-EVACUATION orders have a range 0-1
NormPreAct	The normalised order of their experience, i.e. order has a range 0-1

10.9 DESCRIPTION OF THE DATABASE FIELDS USED IN THE EXPERIENCE MODIFICATION HISTORY TABLE

ExperienceMods HistoryID	The primary key for the EXPERIENCE MODIFICATION HISTORY table.
OldType	The old foreign key of the EXPERIENCE TYPE.
NewType	The new foreign key of the EXPERIENCE TYPE.
Experience-ID	The EXPERIENCE SUB TYPE foreign key.
TimeDate	The date that the change was made.
EntryID	The data extractor that made the change.

10.10 DESCRIPTION OF THE DATABASE FIELDS USED IN THE RELATIONSHIP TABLE

ExperienceMods HistoryID	The primary key for the EXPERIENCE MODIFICATION HISTORY table.
OldType	The old foreign key of the EXPERIENCE TYPE.
NewType	The new foreign key of the EXPERIENCE TYPE.
Experience-ID	The EXPERIENCE SUB TYPE foreign key.
TimeDate	The date that the change was made.
EntryID	The data extractor that made the change.

10.11 DESCRIPTION OF THE DATABASE FIELDS USED IN THE DB CATEGORIES TABLE

CATEGORIES-ID	The primary key for the DB CATEGORIES table.
CATEGORIES-TITLE	The name of the title category.
CATEGORY	A classification for the title

NOTE: these are used for populating combo boxes