In with the Right Crowd

crowd movement and space use in Trafalgar Square during the New Year's Eve celebrations

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0 Abstract

The paper describes a three-year study of the crowd behaviour in Trafalgar Square and central London during the New Year's Eve celebrations. The objectives of the study were to: identify the characteristics of crowd movement, density and congregation, and how this might be related to spatial layout; evaluate how this might impact on issues of public safety, in consultation with risk management experts; and, develop effective crowd management measures in preparation for the 1999 Millennium New Year's Eve celebrations. The study is a useful demonstration of how the well-established observational techniques of the Space Syntax Scientific Research Programme (SRP) have evolved in recent years to enable researchers to investigate the relationship between crowd behaviour and urban morphology. This evolution was necessary because of the inherent problems associated with studying crowds. The resolution adopted was a more balanced approach to data collection, incorporating both quantitative and qualitative observations, the benefits and limitations of which approach are discussed.

1 The Problem of the Crowd

A considerable body of research about how people move and occupy space, and how this is related to spatial layout, has emerged over the last decade from the Space Syntax Scientific Research Programme (SRP) at University College London and other universities around the world (Hillier and Hanson, 1984a; Hillier, 1996; Major et al eds, 1997). These findings include about how the pattern of pedestrian and vehicular movement in cities is related to spatial layout (Hillier et al, 1993; Penn et al, 1998) and how the static use of space is related to the way visibility is structured in the built environment (Hillier et al, 1984b; Campos, 1997). This body of research has recently formed the basis for an investigation of the relationship between spatial layout and how crowds move and congregate.

Relying on the scientific validity of these research findings has been necessary due to the many problems associated with researching crowds. Though these problems are many, during the course of two recent studies of crowd behaviour - conducted by the Space Syntax Laboratory at University College London - three specific problems have emerged which have proven crucial. These studies were the Millennium Crowd Safety Study (which is the subject of this paper) and an impact study of the 'Diana' crowd phenomenon on Kensington Gardens, London (Major et al, 1996; Major et al 1997; Major and Doxa, 1998; Major and Doxa, 1999).

The first is the temporal problem, in that crowd congregation will usually occur over a brief period of time. The effect of this is pervasive in limiting our ability to observe crowd situations. Because a crowd will gather over a compressed period of time, the

08.2

way in which people converge on the specific area of congregation, and then disperse from that same point once the event is over, will also occur over a brief period time. In the case of the New Year's Eve celebrations in Trafalgar Square, crowd convergence, congregation and dispersal will occur in as little as one or two hours, dependent on the weather (1). So there is very little time to observe and quantify.

It is from this that emerges the second problem, what we will refer to as the observation problem. At the same time as the crowd is converging, congregating and then dispersing, movement levels, crowd density and congregation will be variable from minute to minute and location to location. It seems a reasonable conjecture that there will be a spatial logic to the pattern of the crowd but for this pattern to be detected, it must be comprehend as a whole.

However, established observation techniques used within the space syntax programme rely on sample counts taken in several locations over a long period of time - usually collected by a small number of observers, each responsible for several locations - to build up a picture of how a spatial network functions as a whole. It is precisely the configurational pattern of spatial networks which confers consistency to movement patterns over time - in everyday circumstances - and allows space syntax researchers to be successful in collecting vast amounts of quantitative data on movement using sampling. By doing so, a typical space syntax observation study of an urban area will account for 80 to 120 different locations, usually involving only 6 or 8 observers.

In order to rigorously quantify crowd movement levels, one would have to accurately account for variable movement levels from minute to minute (in some instances, extreme variations due to the high numbers of people). This could only be achieved in the traditional manner if a single observer remained stationary at a specific location for the entire period of observation. In these circumstances, a team of 80-120 observers would be required - each responsible for a similar number of locations - to achieve the same level of rigour of an typical observation study. This is clearly not feasible.

Even if a limited amount of sampling was used - say each observer is responsible for 4 locations - an observation team of 20-30 people would still be required. However, even in these circumstances we would be unable to accurately account for variability from minute to minute, increasing the likelihood that a significant portion of the movement data could be missed. For example, what if congestion occurs and the crowd becomes stationary for the period of a sample count? The numbers would suggest a movement flow of 0 per minute which, while technically correct, would inaccurately describe the prevailing conditions at that time, i.e. was the movement flow 0 per minute because the crowd was congested or because nobody was observed. Now clearly if there were only a single occurrence of this situation than researchers could successfully account for such an aberration but what if this occurs half a dozen times in different locations at different times. The picture we were trying to build up would become meaningless. Beyond this, there is an even simpler reason why traditional sample counts are impractical and this the question of whether an observer 'on the ground' can accurately count such high numbers of people. Our experience suggests not. There are several constraints placed on an observer's ability to count, the most obvious being visibility in that the observer would need to see the crowd from above to be ensure accuracy.

This leads directly to the third and final problem, that of resourcing. It is possible to accurately quantify crowd characteristics using technological solutions, for example video to record crowd movement or photography to record crowd density. Researchers are then free to then analyse this documentation at a later stage. However, we are still presented with the same problem as above. In order to build up a rigorous picture of crowd movement as a whole, we would require videos positioned at scores of locations. Experience has shown that Close Circuit Television (CCTV) is not a viable option. CCTV is severely limited in that cameras are usually located to assist the police or private security firms responsible for individual buildings. This means that CCTV is located for the surveillance of access points to buildings, i.e. for the protection of private property. It is an impossible proposition to persuade scores of property owners in the area to forgo their security measures for protecting their property in order to assess movement flows along street segments, especially during a crowd situation. Even if possible, CCTV cameras are seldomly located in optimal locations to video movement flows at the required locations, either horizontally in plan or vertically in section.

Still photography is useful but in only quantifying crowd density levels and recording specific problems as they occur. It is severely limited by its very nature when it comes to movement. The only feasible solution is the purchase, locating, mounting and operating of cameras by researchers themselves. The costs of this, in terms of equipment and manpower, is prohibitive to say the least. This is because we would still need to video 80-100 locations and the man hours involved in properly assessing crowd movement for so many locations using video would be exponentially multiplied - compared to normal studies - when you take into account the need to both film the footage and then later review the footage on several occasions. Government and police authorities - already constrained by tight budgets - simply can not justify the high costs of such an approach for what are generally viewed as one-off situations. What this means is there is simply not enough funding available to quantitatively assess crowd phenomenon on a large scale using video technology.

At the same time, the purely qualitative approach favoured by risk management consultants - who generally have a background in psychology - for observing crowds is severely limited in three ways. First, the quality of information gathered will be strongly dependent on the previous experience of the observer. An inexperienced observer may not know what to look for while observing a crowd whereas an experienced observer will be able to compare and contrast what is being seen with what has been previously observed. Second, the information gathered about the crowd will become strongly biased to 'local' occurrences in that the observer will be clear about what occurred at what specific location and time but will be limited in assessing the large-scale or global effects on the crowd, if any. Finally, the information gathered based on qualitative observations will be viewed as subjective in nature - often no matter how experienced the observer - and hence open to interpretation by others. This means that any advice provided to authorities can be more easily rejected in favour of other considerations, i.e. costs or politics, since the advice can be put down

08.4

to opinion rather than objective assessment.

2 A Third Way

In the United Kingdom, the Hillsborough and Heysel disasters of the 1980's raised awareness about the public safety issues associated with crowd congregation. These well-publicised and tragic events eventually led to the Taylor Report recommendations on stadia design and provisions for managing crowds. However, devising effective crowd management measures has proven more difficult for authorities when events occur over a large urban area, for example the New Year's Eve celebrations in Trafalgar Square or Edinburgh, the Notting Hill Carnival or the Lord Mayor's Show in the City of London. In these cases the findings of the Taylor Report are of limited use since the recourse to changing the built environment is limited. The lack of quantitative data on the way crowds move, use and congregate in urban space has been an area of great concern to both government officials, who must ensure that the built environment can withstand the 'burdens' associated with large crowds, and the police, who are responsible for ensuring public safety in such situations. It was partially because of this need to innovate a new approach which led to the recent collaboration between Risk Management Consultants and the Space Syntax Laboratory on the

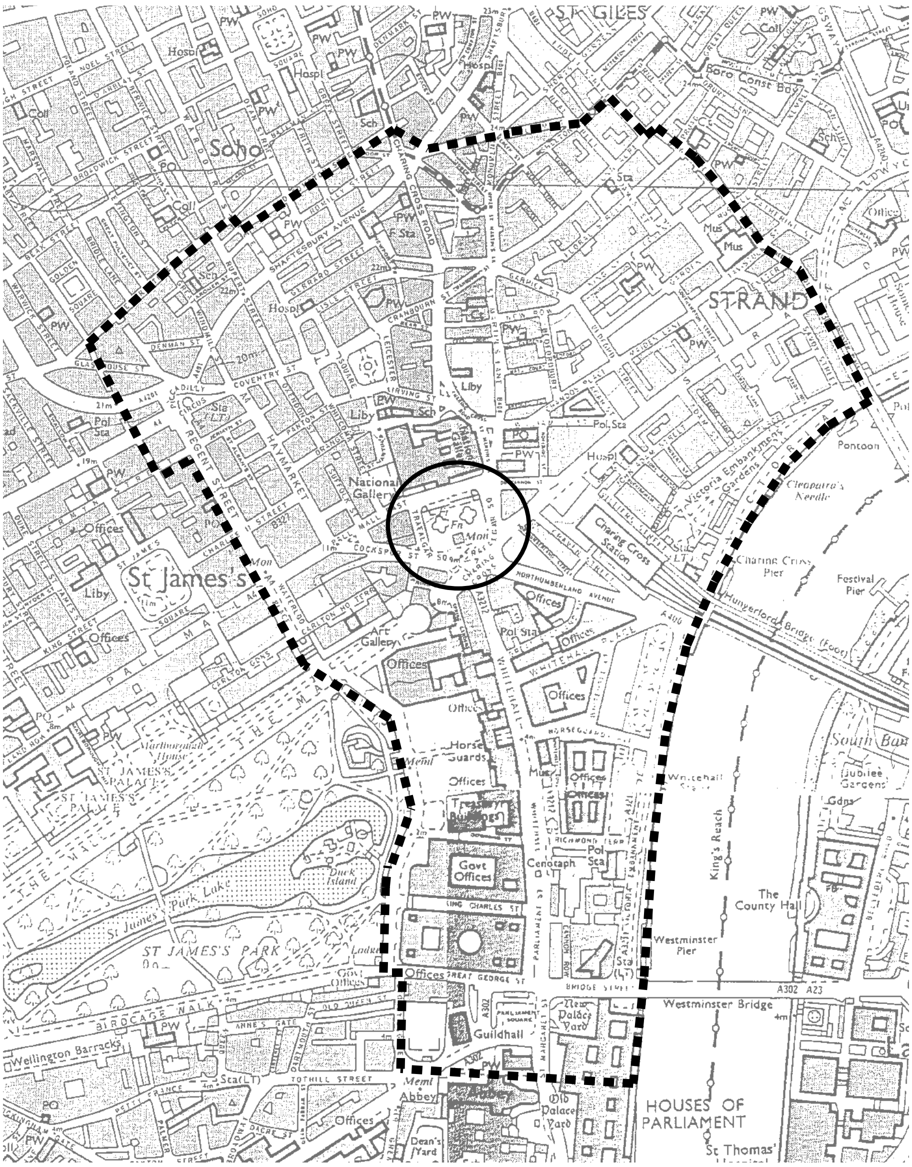

Figure 1. Area of study for the Millennium Crowds Safety Study with Trafalgar Square circled.

Millennium Crowd Safety Study commissioned by the Westminster Public Safety Committee (comprised of the City of Westminster, Royal Parks Agency, Department of Culture, Media and Sport and the Metropolitan Police). Figure 1 shows the area of study. Figure 2a shows a closeup of Trafalgar Square.

The government and police authorities in this case required both detailed information about the crowd in specific locations and general information about how the crowd used the area of central London as a whole on New Year's Eve. This was so they would be better able to anticipate what will occur when the crowd gather on New Year's Eve as well devise the appropriate contingencies for different scenarios. This was more likely to involve concerted action 'on the ground' at the time but also could encompasses physical changes to the built environment.

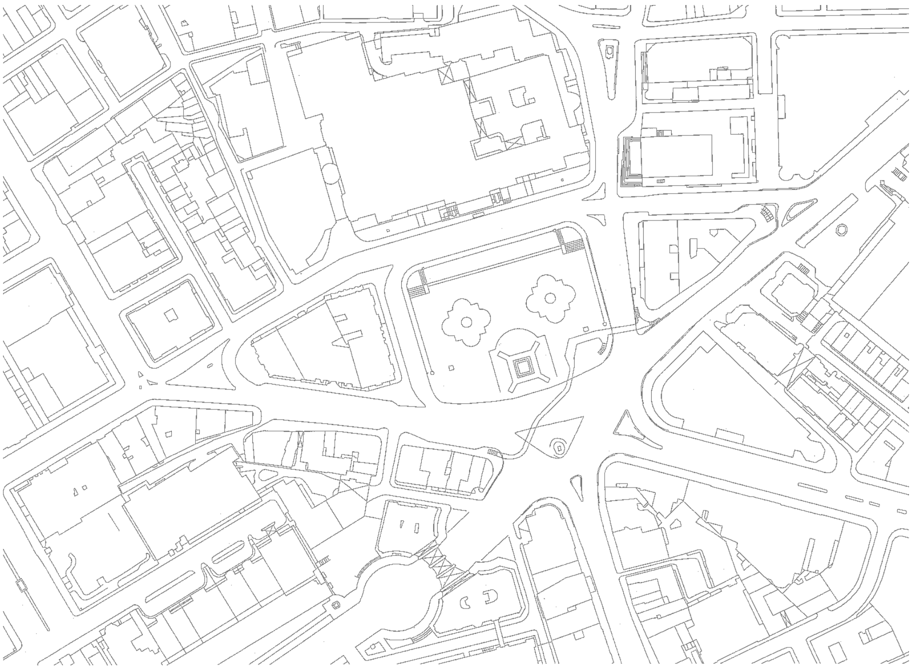

Figure 2a. Close-up of the plan of Trafalgar Square.

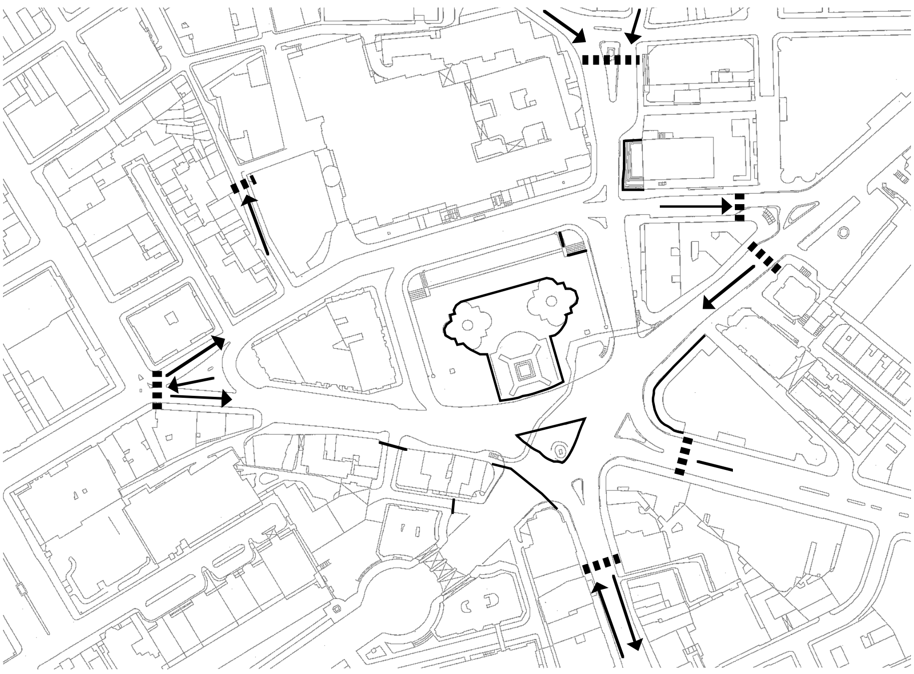

Figure 2b. Close-up of the planof Trafalgar Square and the crowd management system used by the Metropolitan Police. Entry and exit-only cordons are indicated by the arrows. The actual location of entry and exit cordons are indicated by the dashed line. Areas cordoned off from public access are indicated by the black lines.

Over the past three years, we have sought to develop a methodology for observing crowd density, patterns of movement and congregation. The objective has been to overcome the problems discussed above so that researchers can better understand the nature of the crowd phenomenon and more effectively advise the police and government on their provisions for managing the crowd. This methodology combines the high-cost merits of quantitative observation and data collection with the low-cost merits of qualitative observation. By this we mean;

• Video observations, whereby the numerical data on people flows could be collected and quantified;

• Photographic observations, whereby numerical data on crowd density could also be collected and quantified; and

• Limited random sampling, which can be easily and accurately accomplished within the available time constraints, primarily involving people following or gate counts earlier in the evening (i.e. before 22.30);

• surveying, based on a questionnaire distributed to the crowds gathered in Trafalgar Square before midnight; and,

• qualitative observations based on observer experience.

Quantitative observations were carried out to provide researchers with a detailed 'local' view of the crowd while qualitative observations - tied directly to previous findings about how people move and occupy space - were used to construct a 'global' view of the crowd. By local, we mean a limited and well-defined location. By global, we mean a large urban area incorporating a spatial network.

This has resulted in an evolution of the quantitative observational techniques used within the space syntax programme to incorporate the qualitative views of experienced observers, linked to a greater reliance on previous findings, i.e. assuming their validity rather than seeking to repeat and confirm them. Based on this 'third way' of conducting observations, we have been able to provide advice to government and police authorities which is objective in its parts but reasoned conjecture in its whole, but a conjecture which is also based on a detailed and objective understanding of the way the area functions in normal circumstances. In the next section we will briefly summarise some of the key findings to arise from the taking this approach, and their implications.

3 Crowd Movement Before Midnight

Figure 2b shows a close-up of Trafalgar Square with the crowd management measures of the police for New Year's Eve indicated, including the position of police cordons and sterile areas. Movement in Trafalgar Square before 23.00-23.30 is characterised by two types of movement, to-movement and through-movement (2). Both types of movement are characterised by a pattern of crowd 'circuiting'. To-movement is movement which passes through the police cordons and remains in square. Once people enter Trafalgar Square they tend to do one of two things, either they immediately find a location to become stationary, that is they pick their spot for the night to view the celebrations, or they continue to move internally within the square, circulating around its edges. We could term this 'local' circuiting. It is local in the sense that it is limited to the square itself. Through-movement is also characterised by circuiting which we will refer to as 'global' circuiting in that people will enter through one police cordon, walk through the square (or perhaps around it once) and exit the square through another police cordon, see Figure 3a. This pattern of circuiting is global in nature because it is characterised by movement which incorporates the spatial layout of the larger area, rather than just the square itself. Basically these are people who have arrived in central London for the New Year's Eve celebrations but who are not yet ready to become static participants. What they do is they move into the square, have to look around to see what is happening or who is there, and then they exit into the surrounding area eventually to come back again. Figure 3b shows a diagrammatic representation of this circuiting pattern in and through Trafalgar Square. Of these two types of

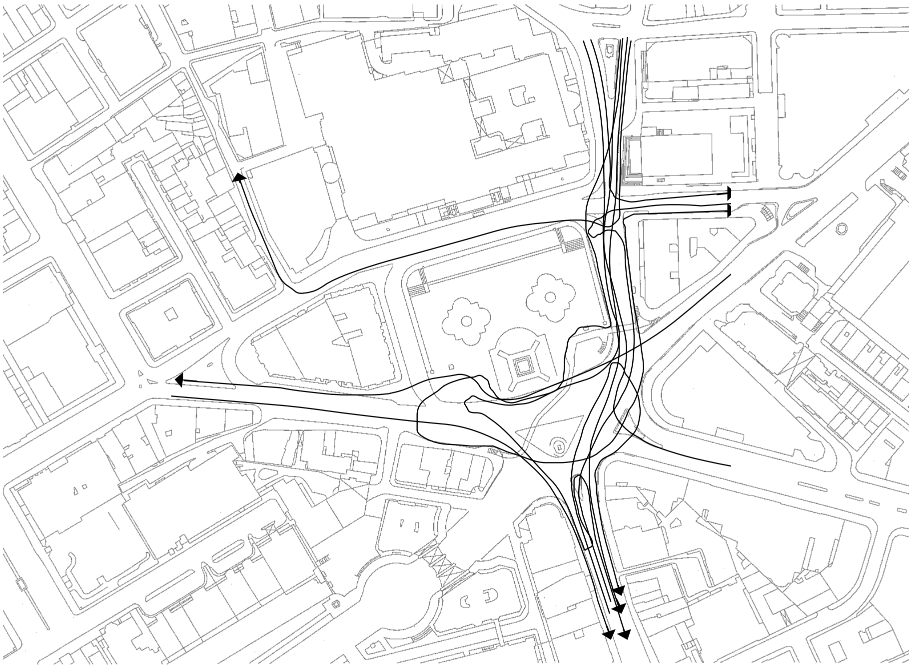

Figure 3a. Random sample of 'global' crowd circuiting through Trafalgar Square on New Year's Eve.

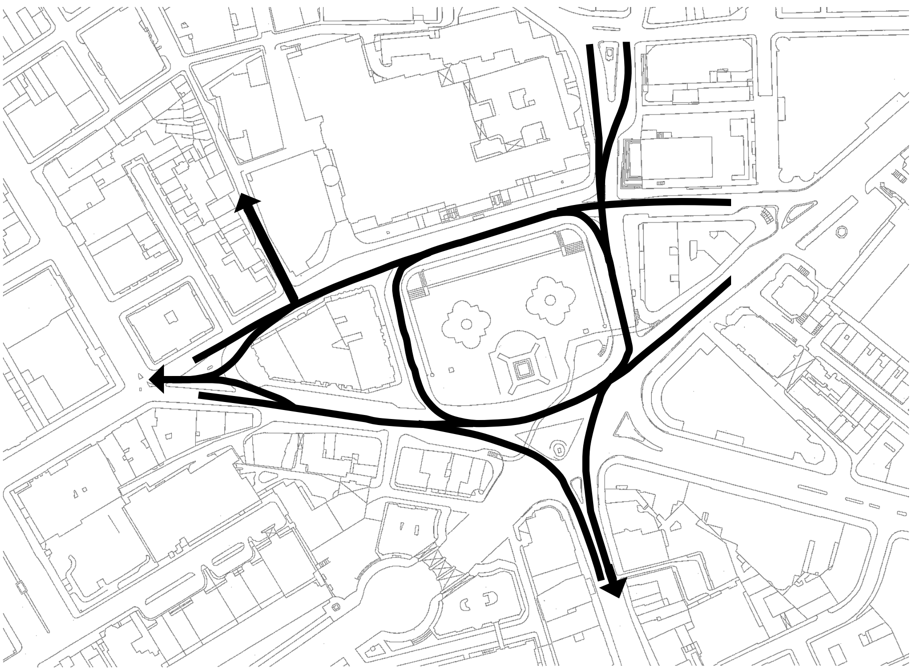

Figure 3b. Diagrammatic representation of global crowd 'circuiting' through Trafalgar Square on New Year's Eve.

Figure 4. Distributed axial model showing the pattern of global integration for all lines within 3 changes of direction from Trafalgar Square (within the confines of the study area), treating Trafalgar Square as inaccessible due to the police cordons.

circulating, global circuiting is clearly a more dominant characteristic of the crowd.

In the larger surroundings of central London, the pattern of movement appears to be largely consistent with the everyday pattern of space use (except for the 15 minutes either side of midnight). This pattern is strongly related to the configurational pattern of the area as a whole, treating Trafalgar Square as inaccessible with the differences between everyday levels and New Year's Eve being that movement is simply exponentially increased on New Year's Eve. Figure 4 shows the pattern of global integration in the distributed model of the axial map, incorporating only those lines within 3 changes of direction of Trafalgar Square (and within the confines of the study area). We can see that integration is strongly focused along the east-west corridor from Covent Garden along Long Acre, Cranbourn Street through Leicester Square to Coventry Street and further on to Piccadilly Circus (we will refer to this hereafter as the Coventry Street corridor). This pattern is very consistent with the dominant pattern of crowd movement on New Year's Eve before 23.45 and after 00.15.

Movement rates through the police cordons was taken in the first year of the study and, though these are rough estimates based on both sampling and video recording, they provide a good picture of crowd movement over time. Figure 5 shows the bar chart of crowd movement through the police cordons over the evening before midnight. We can see that movement levels increase steadily until 23.15, when there is a sharp peak. Levels of movement then drop momentarily only to begin to climb again to higher levels in the period immediately before midnight. We believe this sharp increase is systematic of the pubs letting-out in the area. The pubs close at 23.00 in England - even on New Year's Eve - unless they have obtained a special license. This chart formed the basis of one of our recommendations (later agreed) which was the blanket extension of licensing hours. The objective of this was to keep a large number of people in the clubs or pubs until well after midnight. The New

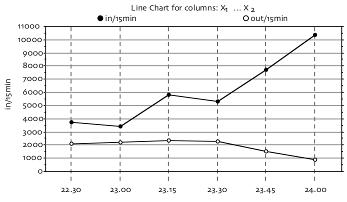

Figure 5. Time chart of movement into and out of Trafalgar Square through the police cordons until midnight.

Year's Eve Millennium celebrations on 31 December 1999 will be the first year in which these extended licensing hours are in effect.

The movement counts conducted in the first year of the study also formed the basis of the hypothesis that crowd movement was characterised by a pattern of circuiting through the square before midnight. As we saw above, this was later confirmed in the second and third year of the study. Figure 6a shows the relationship between inward and outward movement at all police cordons. It indicates that those cordons with a high level of inward movement will generally have a low level of outward movement, and vice versa. Figure 6a-f shows the relationship between inward movement at a single cordon and outward movement at another cordon. We can see that the relationship for each correlation is also negative. The exception is the relationship between inward movement at The Strand and outward movement at Whitehall, which is positive. We believe the relationship between these two cordons is positive because of their relative location within the square and in relation to each other. A person entering at The Strand cordon can move north after entering and circulate internally around the square. By then exiting through the Whitehall cordon, this person will have completely circumvent the entire square, i.e. they get to see everything happening within it, without having to turn back on themselves. The same is not true in the opposite direction, hence the relationship is negative. These correlations form the initial basis of the crowd circuiting hypothesis.

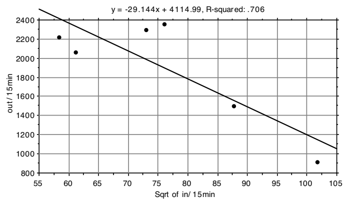

Figure 6a. Correlation between inward movement and outward movement at all police cordons.

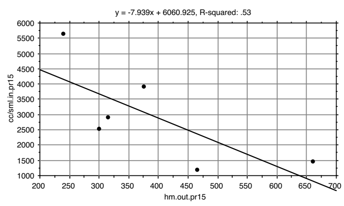

Figure 6b. Correlation between inward movement at Charing Cross and outward movement at Haymarket.

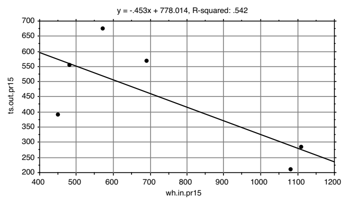

Figure 6c. Correlation between inward movement at Whitehall and outward movement at The Strand.

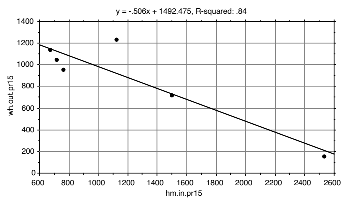

Figure 6d. Correlation between inward movement at Haymarket and outward movement at Whitehall.

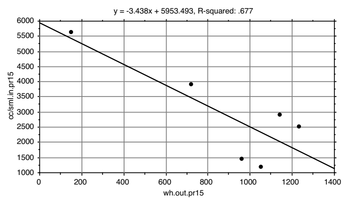

Figure 6e. Correlation between inward movement at Charing Cross and outward movement at Whitehall.

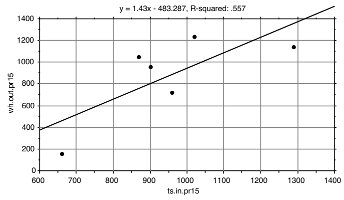

Figure 6f. Correlation between inward movement at The Strand and outward movement at Whitehall.

4 Crowd Congregation and Density at Midnight

The police have intuitively known for years that the crowd density, and hence the total number of people in the square, at midnight is highly dependent on the weather. It is common sense really, cold weather-less people, warm weather-more people. Crowd density counts were made during the course of the study to estimate the total number of people in Trafalgar Square at midnight. These counts bear this truism out. Figures 7, 8a-b and 9a-b shows the density counts made of the crowd at the southeast and southwest corners of Trafalgar Square at midnight for the 1996 and 1997 celebrations. These counts were made by using still photographs or frame grabs from video and then overlaying a 10m x 10m grid over the top of Trafalgar Square in plan. This grid was then transcribed into perspective over the top of the crowd and simple head counts were then made. The weather in 1996 was cold and snowy whereas the weather in 1997 was warm and pleasant. We can see how the crowd density (calculated at an average of number of people per square metre) has increased from one year to the next. Based on these calculations, in tandem with other random sample counts in other parts of the square and measurements of the maximum metric area available for stationary crowds, we were able to provide a reasonably accurate estimation of the total number of people in the square: 48,000 in 1996 and 66,000 in 1997. This represents a 38% increase in the number of people coming to Trafalgar Square for the celebrations in 1997 compared to 1996. We believe that the majority of this increase can be attributed to the weather.

A direct impact of the fair weather and greater numbers is that people enter and become stationary in the square earlier, around 23.00-23.15 as opposed to 23.15-23.30. This has the effect of limiting the scope of available space for crowd circuiting through the square, or internally within it, since people will become stationary much

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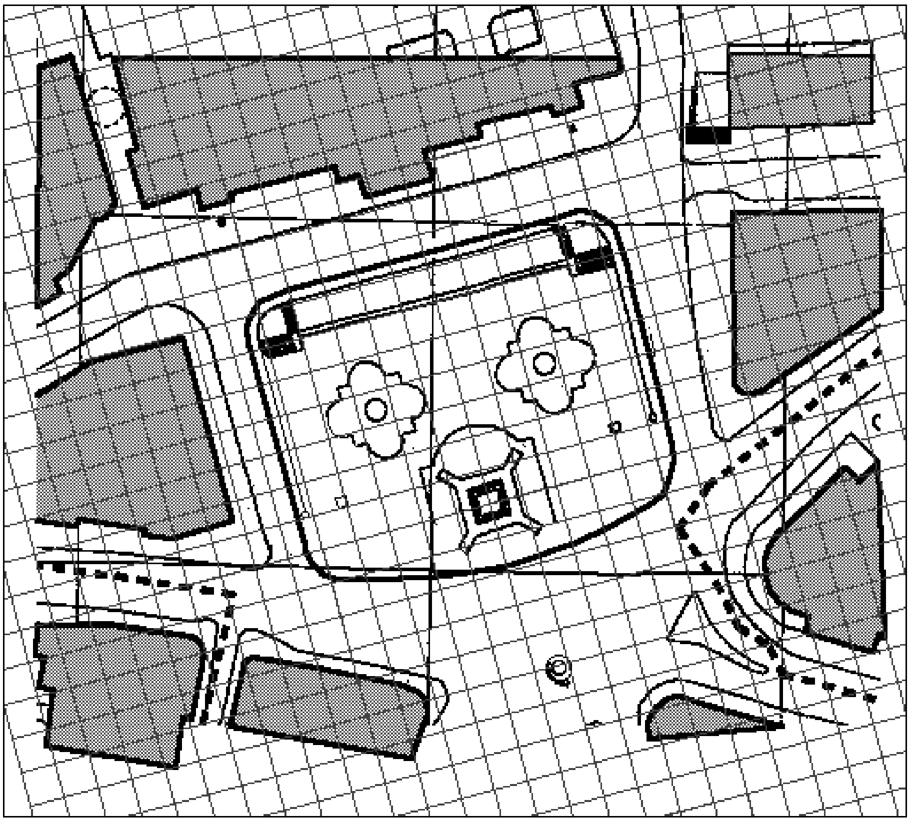

Figure 7. Map of Trafalgar Square with a series of 10 X 10 m grid superimposed.

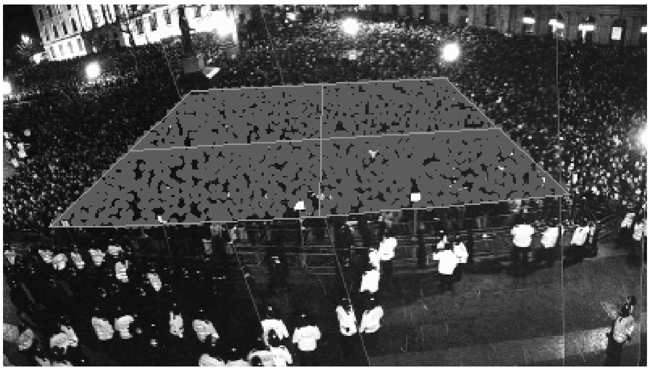

Figure 8a. Head counting of the crowd at the southeast corner of Trafalgar Square, New Year's Eve 1996.

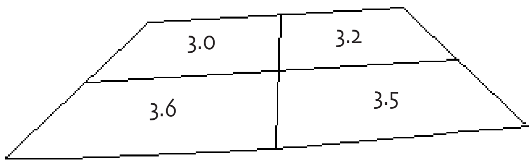

Figure 8b. Estimate of crowd desnity (number of people per square metre) at the southeast corner of Trafalgar Square, New Year's Eve 1996.

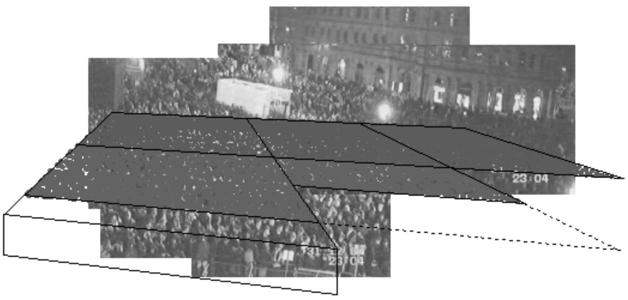

Figure 9a. Head counting of the crowd at the southeast corner of Trafalgar Square, New Year's Eve 1997.

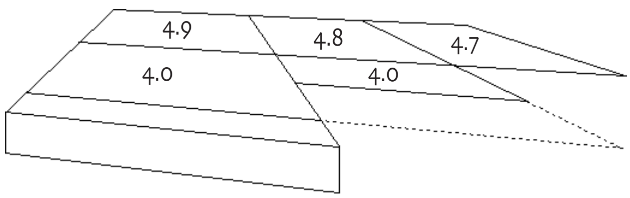

Figure 9b. Estimate of crowd desnity (number of people per square metre) at the southeast corner of Trafalgar Square, New Year's Eve 1997.

more quickly in fine weather. Also, more time will be required for people to pass through the police cordons since the crowds at the cordons themselves will be more dense earlier. Progress is also slowed considerably by police checks at the cordons for alcohol, fireworks and breakables (i.e. bottles). In fine weather, once people are through the cordon more will elect to stay rather than attempt to exit and re-enter again.

Despite the differing numbers of people in the square during different years, the way in which the square becomes occupied is both consistent and strongly related to spatial layout. Figure 10 shows the pattern of stationary occupation during a typical summer lunch time in Trafalgar Square (Hillier et al, 1998). We can see that there is a strong bias to the southeast corner of the square. This is typical for most times of the day and most days of the year. Consequent research has demonstrated that this southeast bias is strongly related to visibility, in that it is this location of the square which possesses the most strategic views of central London. There are strong lines of sight from this point down The Strand, The Mall to Buckingham Palace, Whitehall to Parliament and Northumberland Avenue to the River Thames. A slightly more strategic position is available directly to the south of Lord Nelson's column at the Charles I traffic island but one has to risk 'life and limb' to cross the vehicular flow around the square to reach it. Despite this several people do take the risk as demonstrated by the grey lines in Figure 10, which indicates illegal pedestrian crossings. The views in the south of Trafalgar Square are much more strategic than any other location, including the geometric heart of the square itself. This can be seen in Figure 11a-b. On New Year's Eve this traffic island is cordoned off by the police and inaccessible to the general public, so the best strategic view available is from the southeast corner. The way the crowd becomes stationary in Trafalgar Square becomes strongly related to the strategic views available, following a simple rule of 'best view available', resulting in a very distinctive and systematic manner: southeast, south/southwest, east and north, west and then finally the extreme north near St Martin-in-the-Fields Church and west along Cockspur Street and Pall Mall. This indicates that the pattern of crowd congregation is strongly governed by visibility, and hence spatial layout.

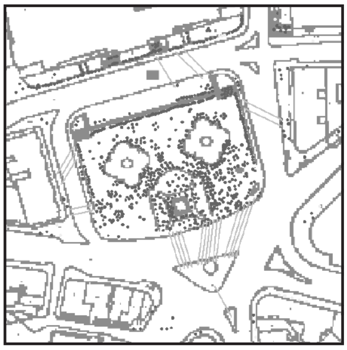

Figure 10. Static use in Trafalgar Square during a typical summer lunch time period.

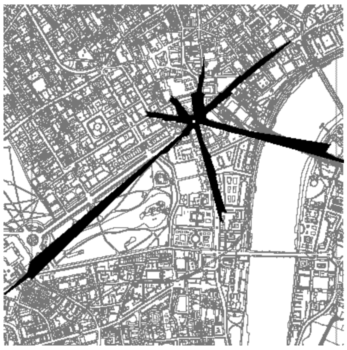

Figure 11a. Isovist field from the Charles 1 traffic island in the south of Trafalgar Square

Figure 11b. Isovist field from the geometric centre of Trafalgar Square

5 Crowd Dispersal After Midnight

The way in which the crowd disperses after midnight is characterised by three types of movement: destination-orientated; dispersal and convergence, see Figure 12. The first is based on attraction whereas the second and third are strongly related to spatial layout. The cordons after midnight are basically thrown open by the police, i.e. anyone can exit via most cordons, in an effort to clear the square as quickly as possible. Destination-orientated movement is focused on two primary locations, Charing Cross Station (mainline and underground) and the temporary bus depot at Aldwych. This movement is composed of people who want to leave the area immediately after midnight via public transportation. Dispersal movement is focused at Piccadilly Circus, in that those who have made their way out of the square to Piccadilly Circus then disperse outward along the main routes available from this area (10 in all, counting the underground station access). Convergence movement is focused on the north side of Leicester Square along what was earlier referred to as the Coventry Street corridor. This is because of the strategic importance of this route as the only available east-west route in the area (in lieu of the management measures in Trafalgar Square).

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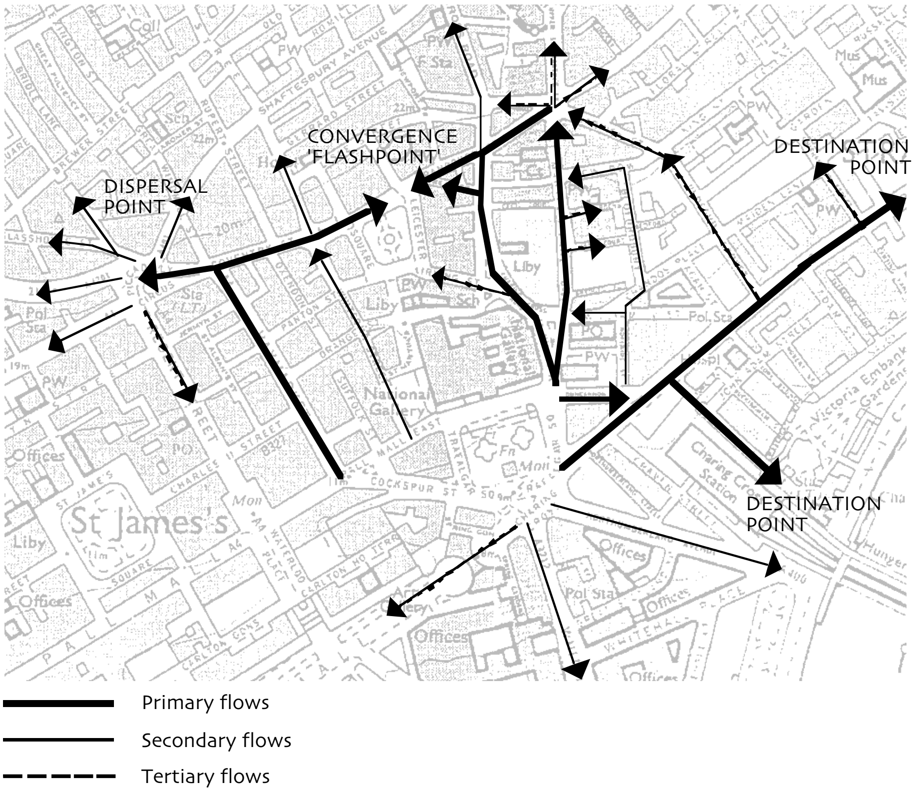

Figure 12. Pattern of crowd dispersal from Trafalgar Square after midnight on New Year's Eve.

What occurs is that large numbers of people exit the square via The Strand, Dunncannon Street, Charing Cross, Whitcomb Street and Haymarket and begin to recirculate in the area. Almost by definition, at some point in the night they will have to access the Coventry Street corridor. When this occurs movement from the east and movement from the west will converge along the north side of Leicester Square, especially in the first half-hour after midnight. In previous years this has resulted in very severe congestion and crushing problems in Leicester Square as large numbers of people tried to move in different directions.

The location where the crowd converges along the Coventry Street corridor is accentuated by the three components: spatial layout, land use patterns and the location of underground stations. Each of these components are biased to the north, meaning throughout the night the northern sections of the study area will be used to a much greater degree than the south. Figure 13a shows the distributed axial model of the area, incorporating all lines within three changes of direction of Trafalgar Square, including those axial lines lying outside the study area. We can see that the density of the spatial network is strongly biased to the north, meaning that they are simply more spaces easily accessible from Trafalgar Square to the north rather than to the south. Also, on this axial model we have plotted the locations of all the underground stations available within this system, see Figure 13b. Again, we can see that there is a strong northern bias with 11 stations available in the north (including as far away as Goodge Street Station) and only 6 stations available in the south (Charing Cross is not considered since it is located adjacent to the square). Figure 13c shows the pattern of ground level land uses in the study area. Though this graphical representation is originally in colour, we can make out that the north is largely characterised by three types of land use: retail, restaurants, and drinking establishments (pubs, clubs and bars). In contrast, the south is largely characterised by government buildings and offices. On New Year's Eve this pattern of land use accentuates the differences between

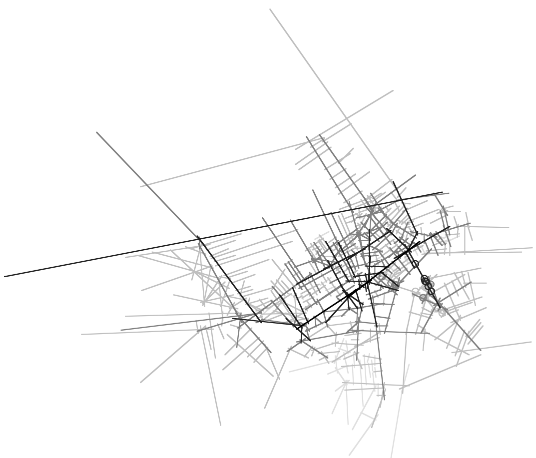

Figure 13a. Distributed axial model of all lines within three changes of direction (including those outside the study area). This map shows the pattern of the log of global intergation.

Figure 13b. Axial model with the location of all accessible underground stations in the area indicated in black.

Land Use Map • Central London

Survey: December 1996 - January 1997

PUBLIC ADMINISTRATIONS
Local Government
National Government
Foreign Governments

PUBLIC INSTITUTIONS
School
Religious Buildings
Cultural Institutions

RETAIL AND OFFICES
Shops, Stores
Commercial Services
Workshops, Warehouses

LEISURE
Restaurant
Pubs, Bars
Clubs, Discos
Theatres, Cinemas

ACCOMODATION
Hotels
Residential Buildings
Hospitals

Transportation

Figure 13c. Survey showing the pattern of ground level land use in central London. NOTE: This representation was originally produced in colour.

08.14

the north and south as the buildings in the south are closed while almost every establishment in the north is open. This means there are simply more destinations available in the north compared to the south on New Year's Eve.

Obviously, it is impossible to altered this spatial and functional bias to the north on a large scale. However, two specific recommendations were made to help alleviate the problem along the Coventry Street corridor. First, a funfair is normally located in Leicester Square during New Year's Eve. It was our evaluation that this funfair eliminated over half of the pavement width normally available in Leicester Square. Its removal was recommended and accepted. Second, as part of the initial refurbishment proposals several years ago for Leicester Square, provision was made for an artist's enclosure in front of the Swiss Centre, near the junction of Coventry and Whitcomb Street on the north side of Leicester Square. This enclosure represented a waste of pavement width, eliminating more than half of the pavement width for pedestrians. It was also a perfect illustration of the movement economy in practice since artists located themselves along the outside northern edge of the enclosure in order to be near the main movement flows, i.e. near their potential clients. This had the impact of generating congestion problems along the northern edge of the enclosure (also related to the design of pedestrian crossing at Whitcomb) not only on New Year's Eve (Figure 14) but also during most times and days of the year. Its removal was recommended and accepted. Our initial evaluation of these changes in Leicester Square has been guardedly positive that these changes were successful to alleviating the congestion problems along the north side of Leicester Square - not only after midnight on New Year's Eve but also during the everyday.

In several instances, this problem of crowd convergence on the north side of Leicester Square was accentuated by another common crowd characteristic, what we will refer to as 'spontaneous stationary activity'. This is the tendency for people in the crowd to become static instantaneously anywhere in the area at any moment. It is interesting that this most often occurs in the middle of main movement flows. Spontaneous stationary activity is more apparent in fine weather and after midnight. This crowd behaviour also does not appear to be constrained in any way but high density or congestion. Finally, there appeared to be some additional effects of the weather in how the crowd behaves after midnight. First, in fine weather not only do people arrive earlier in Trafalgar Square but they also stay longer. Second, after leaving Trafalgar Square they stay in the central London longer. This actually has the benefit of reducing the strain on the public transportation system in the area immediately after midnight (underground and buses). This is because in poor weather people will tend to travel immediately to the underground stations and buses in order to leave the area. This often results in major congestion problems within stations, outside their entrances and in the areas around the bus stops.

Figure 14. Wasted pavement width in the centre of the 'artists enclosure' in front of the Swiss Centre and the resulting crowd congestion to the north of it at approximately 22.00.

6 Implications of the study

We have review just a few of the findings to arise out of the study. Additional research work was conducted on pedestrian-vehicular conflicts and how these might be alleviated by extending the traffic exclusion zone in central London, both physically and over time. This work involved using the vehicular model of Greater London, modelling the effects of the traffic exclusion zone and of possible changes to the system, i.e. closing certain roads, opening others. Also, experimental modelling of both Trafalgar Square and the study area as a whole is being conducted using the recently developed Isovist Integration Analysis software package (Penn et al, 1999; Turner et al, 1999). For example, this is being utilised to better understand how the pattern to the way the crowd becomes stationary in the square might be related to small scale details in its spatial layout, i.e. pedestrian barriers, street furniture. We are also using this software to better understand the effects on crowd movement within the square of the one-way cordon systems constructed by the police. This research continues but the findings to date suggest that this balanced approach incorporating qualitative and quantitative observations has been successful in helping researchers to overcome the problems of observing crowds. It has allow us to more effectively build up a picture of the crowd phenomenon as whole than was previously possible and to more effectively advise government and police authorities about their crowd management measures. Admittedly, this approach relies more heavily on reasoning and experience rather than on the volumes of numerical data and statistical correlations which characterises most space syntax research. This has been of necessity due to the limits of time and resources however, we would suggest that enough of an quantitative edge has been retained to make more objective the qualitative aspects of the methodology.

There are limitations to this approach in that some qualitative observations will, rightly so, still be viewed as subjective and open to interpretation by the authorities. They will often require documentary evidence before resources are allocated to addressing the problem. But this, in its own way, is beneficial in that government and police authorities - who have their own experience of crowd situations - will serve as a double-check on the research work, confirming it where their own intuitions agreed and questioning aspects which require more objective evidence. In this way, the client-consultant relationship becomes much more collaborative, helps to ensure the validity of the research and hopefully, contributes positively in facilitating public safety.

7 Conclusion

The paper has demonstrated how careful observation and analysis of crowd movement and space use can begin to help researchers understand the relationship between urban morphology and crowd behaviour. This was based on the development of a ‘third way’ methodology which struck a balance between the low-cost benefits of qualitative observations to provide a global view of crowd situations and high-costs benefits of quantitative observations to provide a local view of the crowd. It was demonstrated that before midnight crowd movement in Trafalgar Square is characterised by a pattern of ‘circuiting’, both internally within the square and externally using the larger urban context. At midnight, an new method for calculating crowd density was discussed. It was used to show how crowd density will be different for different areas of the square and how the way in which the square fills up with static participants appeared to be strongly related to visibility. It was also useful in objectively demonstrating how the variability of total crowd numbers was dependent on the weather. After midnight, crowd dispersal from the square is also strongly influenced by spatial layout and the location of specific attractors, such as public transportation nodes. Finally, it was shown how this knowledge base was used as a decision support tool for proposing and evaluating crowd management measures aimed at improving public safety in preparation for the 1999 Millennium New Year's Eve celebrations.

Notes

1 - In the case of Trafalgar Square on New Year's Eve, during fine weather the crowd will congregate over a longer period of time whereas in poor weather the period of crowd congregation will be shorter.

2 - The extent to which the square is characterised by these two types of movement is also strongly dependent on the weather. In fine weather, the square fills up much faster and the potential for movement in the square becomes more limited, more quickly.

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