

Crime on Public Transport: 'Static' and 'Non-Static' (Moving) Crime Events

Andrew D. Newton
University of Huddersfield

ABSTRACT

This paper presents a theoretical discussion conceptualising some of the problems evident in analysing patterns of crime and disorder on public transport, and the environments within which such crimes occur. The public transport system is a multifaceted arena, with a complex interaction of settings (buses, trains and trams), facilities (stops, stations and interchanges) and users (staff and passengers). The design of these facilities, and the internal (inside a vehicle) and external (that a vehicle traverses) environments may all influence the level of crime experienced on the system. Thus, examining the manifestation of crime on public transport systems becomes a highly complex process. Current methods of crime analysis focus on 'static' crime events with a precise location (x,y co-ordinate). However on public transport crime may occur on a moving vehicle (non-static), and it is difficult to define a single location for this. For the purposes of analysis, it is contended that non-static crimes have a location, between two points and two times, represented as a single snapshot of time. Thus, in addition to analysing static crime events (points and areas), attention should also be focussed on how to analyse non-static (linear) crime events. Two possible techniques for such analysis are presented, alongside a discussion of the difficulties in collecting accurate and consistent data on crime on public transport. It is anticipated that an increase in the availability of such data will enable future empirical testing of the ideas presented.

KEYWORDS: environmental criminology; public transport; 'static/moving' crime events; spatial analysis.

This paper outlines the complexities involved in examining the manifestation of crime and disorder on public transport, particularly in applying the traditional analysis techniques commonly used within the field of environmental criminology. It begins by highlighting the importance of examining crime on public transport and the limitations that exist in current data, and suggests some reasons for the paucity of studies evident. Previous research that attempts to explain crime on public transport with reference to the characteristics of the area a route traverses is utilised, in order to consider whether environmental criminology rationale can be applied to examine crime on public transport.

The analytical techniques used within the field of environmental criminology are then examined, and are found to focus primarily on examining crime events that have a specific location (static events). However on the public transport system crime events may happen on a moving vehicle, which are difficult to locate, and hence analyse spatially. Thus the public transport arena contains a mixture of static and non-static events. Although techniques to examine static events are well established, this is not the case for non-static events. Two techniques are suggested to address this problem. Finally, some discussion is provided as to future directions for research, including the need for empirical testing of some of the ideas presented in this paper, and the development of techniques to analyse crimes that do not have a single location.

Crime and Disorder on Public Transport

There has been limited attention afforded to incidents of crime and disorder on public transport, particularly in comparison to the occurrence of such incidents outside of the public transport arena. In the United Kingdom (UK), perhaps the single most conclusive evidence of this is provided by the fact that the police do not record incidents of crime on public transport as a category in its own right, and there is no national or local policing unit dedicated to bus services, although the British Transport Police are responsible for policing rail services. In addition to this, difficulties in obtaining accurate data on the location of public transport crime (described later in this paper) have further restricted analysis into the manifestation and distributions of such crime.

On public transport fear of crime and concerns for personal security, a generic problem in many aspects of society today, are clearly a limiting factor to patronage and levels of usage (Levine and Wachs 1986b; Benjamin et al. 1994; and Ingalls, Hartgen and Owens 1994). The then Department of the Environment, Transport and the Regions White Paper (DETR 1998), suggests that patronage on public transport could be increased by 3% at peak and 10% at off peak times if fear of crime were reduced. A vicious circle exists here, as fuller trains and buses make people feel safer when travelling. Furthermore, a recent survey of both users and non-users of public transport in Merseyside (UK)

indicates that, after service and reliability, over 50 percent of respondents felt personal security should be the priority area for improvement (Baker and Bewick 2001). In addition to the safety of passengers, it is also important to consider the security of staff. Budd (1999) examines risk of violence at work, using data from the 1994, 1996 and 1998 British Crime Surveys (BCS). This report states that public transport staff have a high risk of both 'threats' (5.6% compared to an average risk of 1.5%) and 'assaults' (2.8% compared to an average risk of 1.2%).

This has wide ranging implications, because, as highlighted in the DETR report cited above, public transport is important as a means of gaining access to health, leisure and other facilities, and thus in making a contribution to minimise social exclusion. Furthermore, the environmental benefits highlighted by promoting public transport as a means of sustainable mobility are undermined by real fears of personal security on public transport. Therefore, the reduction of crime and fear of crime on public transport should be viewed as an area of paramount importance.

In order to reduce fear of crime, it is necessary to reassure the public about the safety of using public transport. To achieve this requires reliable information about the nature and extent of crime and disorder on public transport, the "who, what, when, where, and why" questions of crime. A better understanding of the prevalence of crime should then enable appropriate measures to be implemented to prevent and reduce such crime. Indeed, *'the ultimate goal should be to make riders feel safe by ensuring that they are safe'* (Nelson 1997:7). Any measures introduced to address problems of crime and disorder on public transport should be based upon clear and appropriate analysis. This should include reliable information on the levels of crime and disorder on public transport, and on what measures applied where and when are likely to prove successful.

There are a number of problems that exist when attempting to gauge the level and extent of crime and disorder on public transport, that make it difficult to determine whether a gap exists between the 'perceived' and 'actual' levels of crime. This is in part due to the lack of data collected on actual levels of crime on public transport. The amount of under-reporting of public transport crime is also unknown and may, as an underestimate, be 25 to 30 times below the actual level of public transport crime (Levine and Wachs 1986a). Major obstacles to collecting accurate data on public transport crime, particularly in the UK, are that with the exception of data collected by British Transport Police on rail crimes, there is no dedicated unit responsible for policing buses or trams, and there is no requirement to collect data on levels of public transport crime. Although the 1988 Crime and Disorder Act in the UK placed a statutory requirement on local authorities and

police constabularies to produce local crime and disorder audits and strategies on a three-year basis (Crime Concern 2004), this does not require the incorporation of information on levels of crime and disorder on public transport.

Indeed, in a review of the last round of the Crime and Disorder Audits in the UK of 2002, only a limited number of these contain reference to public transport (Crime Concern 2004). Only a quarter of these audits made reference to crime on or near public transport facilities, less than one tenth used data from transit companies (rail or bus operators) and even fewer used data from bus companies. Some of the reasons why this data was not utilised, or perhaps not available, are; that commercial services only provide information on a voluntary basis; staff often will not report incidents (for example, verbal abuse to ticket inspectors) as it is perceived as part of their job, not worth reporting, and or treated as not serious; and that incident reporting forms are not simple to fill in (Crime Concern 2000).

From this it is evident that the prevalence of public transport crime is perhaps an unknown, and that it is important for public transport organisations to address the deficiencies that exist in their crime data, before attempting to implement preventive measures. Without an accurate evidence-base upon which to target resources, it is not only difficult to know where and when to target scarce resources most effectively, but also perhaps impossible to evaluate whether a preventative scheme has been successful or not.

THE ENVIRONS OF PUBLIC TRANSPORT CRIME

A number of studies have examined the manifestation of crime and disorder on public transport. Whilst there is not scope here to provide a thorough review of these, some of the key ideas that stem from previous research will be drawn upon, in order to demonstrate the complexity involved in examining crime and disorder on public transport, and the environment within which it occurs. For a more general overview of studies the reader is referred to Easteal and Wilson (1991); Clarke (1996); Felson et al., 1996; Eck (1997); Loukaitou-Sideris (1999); Smith and Clarke (2000); DTLR (2002); Newton (2004a); and Home Office (2004).

One of the early studies that attempted to explain the prevalence of crime on public transport journeys with reference to the environment a vehicle passes through was work by Pearlstein and Wachs (1982). They examined crime on buses in California, and, for a one-year period, found that only 88 out of 233 routes experienced any serious incidents of crime, and that crime mostly occurred on routes that traversed areas with high crime rates in general. Their research also found that most crime occurred when passenger

volumes were highest, that crime was disproportionately high during the late evenings when violent crimes were prominent, and that theft and robberies were most prolific during the rush hour periods. From this they argue that crime on buses is concentrated both in time and space. A subsequent paper by Levine, Wachs and Shirazi (1986) using survey and observational data at bus stops in Los Angeles, provides further support for the hypothesis that incidents of bus crime tend to be highest on bus routes that travel through high crime areas.

The Pearlstein and Wachs study emphasises that a bus route passes through a mix of complex and heterogeneous environments, and that consequently, in order to meet the problems posed by these differing environments, a range of strategies may be necessary to tackle problems of crime and disorder on these routes. However, this is not unique to the particular mode of transport (buses) that they discuss. On the rail network for example, there have been studies that demonstrate how low crime rates in certain systems can be explained by some aspect of the design of their environment (Gaylord and Galliher 1991; Myhre and Rosso 1996; and La Vigne 1997).

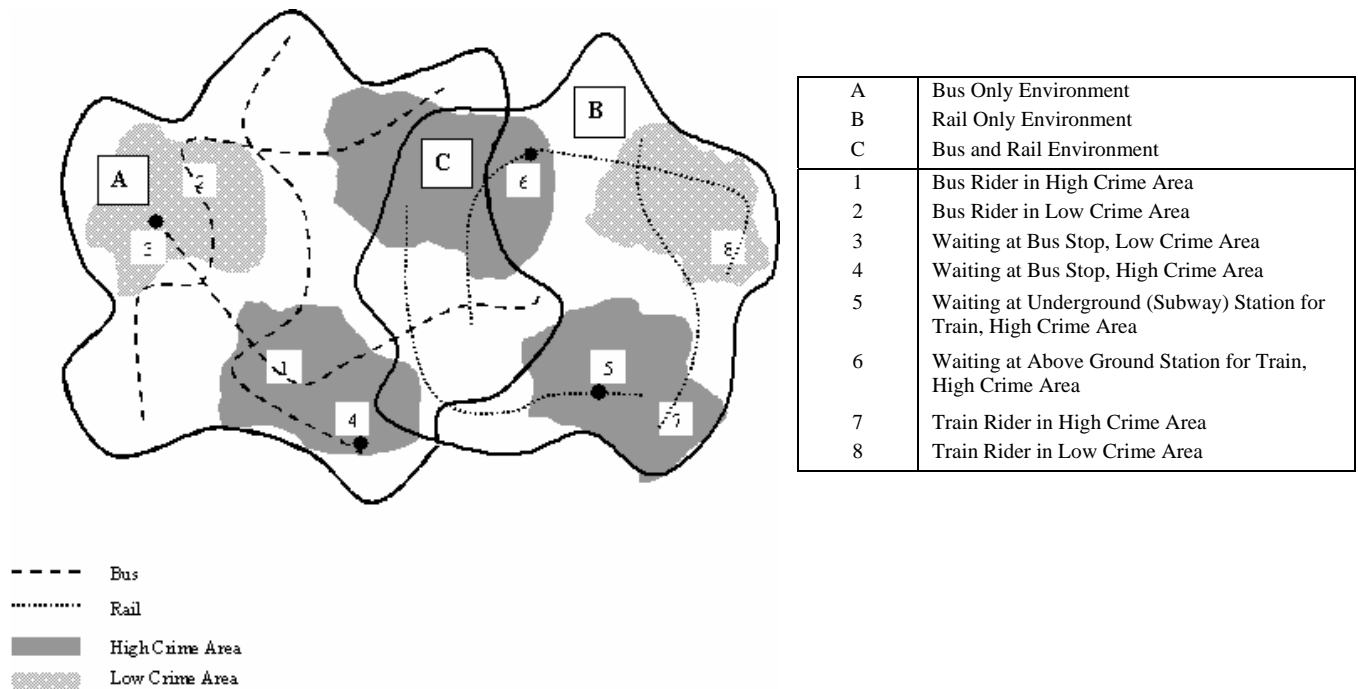
Easteal and Wilson (1991) emphasise that each mode of public transport (they discuss bus, train, taxi, and aircraft, although tram, ferry and other forms of

transport could also be included) exhibits its own set of unique problems. They argue that each mode of transport has a distinct set of problems due to its unique environment, and hence efforts to reduce each type of crime on each system may require a discrete set of solutions. What is important to emphasise here is that each mode of transport has its own unique set of environments that are distinct from other modes of transport.

These two ideas can be combined. Pearlstein and Wachs suggest that the environment that a bus route passes through is a mix of complex and dissimilar environments (this almost certainly applies to other forms of transport). Easteal and Wilson advocate that each mode of transport (bus, train, tram) will traverse its own set of unique environments that are distinct from those of other forms of transport. Merging these two ideas suggests that, within each separate set of unique (dissimilar) environments each particular mode of transport will traverse, there will also be a unique set of environments associated with the particular route travelled by individual vehicles.

This is depicted in Figure 1, whereby area A refers to the bus environment and area B represents the rail environment. The external environments (the physical and social characteristics and crime levels) that influence

Figure 1. The Environs of Public Transport Crime.



these distinctive modes of transport will be different. For example, the environmental influences on passengers 1 to 4 (bus journey) will be different to riders 5 to 8 (rail system). In addition to this, there may be areas with similar environmental characteristics where both rail and bus systems coincide, and this is depicted in area C. Further to this, only two modes of public transport are considered here, but, other forms of transport such as trams would add further dimensions to Figure 1.

In addition to the different external environments traversed by different modes of transport (bus versus train), like modes of transport (for example two buses or two trains) may also pass through different environments. This is illustrated in Figure 1, whereby the solid lines represent how a bus may move through these environments and the dotted lines represent the train journey. At point 1, the user is travelling on a bus in a high crime area, and at point 2 riding a bus in a low crime area. At point 7 the passenger is travelling on a train in a high crime area, and at point 8 the rider is on board a train in a low crime area. All four situations may have a unique environment, and the experience of the passenger may also differ dependent upon whether the bus or train stops or does not stop within these low and high crime areas. This may influence the amount of crime experienced on the route, by transferring offenders and potential targets between these low and high crime rate areas and environments.

In addition to these external influences on a particular mode of transport along the duration of its route, the internal environment of each mode of transport is likely to have a bearing upon the levels of crime experienced by public transport users. A bus or train will have its own unique internal environment when a person is inside a bus or train carriage. The importance of this internal environment was suggested by Mayhew et al. (1976) who examined the effect of supervision on damage to buses in Manchester (in the North West of England). They found that damage was greatest on buses without a conductor, and more prevalent on upper decks, especially the rear seats. They also discovered that on buses with a rear staircase, graffiti and vandalism was more prominent upstairs at the front of the bus. After adjusting the figures to account for where people are likely to sit, they concluded that lack of supervision was an important factor in the occurrence of vandalism and graffiti on buses.

In addition to the influence of the changing external environment a public transport vehicle will traverse, and the internal environment of that vehicle itself, the actual infrastructure of the public transport system is also likely to relate to the prevalence of crime. The interaction between these internal and external

environments occurs at stops, stations, underground stations, and interchanges, and these have an important role in that they provide the only inputs and outputs on the public transport system.

This is also depicted in Figure 1. At point 5, the user is waiting for a train at an underground station in a high crime area, and at point 6 waiting for a train (above ground) in a high crime area. At point 3 the user is waiting at a bus stop in a low crime area, and at point 4 the passenger is waiting for a bus in a high crime area. The importance of this is that the environments at all these points are very different, and their impact upon crime rates is also likely to vary considerably. For example, the high crime rates and environmental characteristics above ground (point 5 above the underground station in Figure 1) are likely to have less of an influence on the passenger in the subway station, than the characteristics at point 6 (waiting at a rail station at street level in a high crime area), and perhaps also at point 4 (waiting at a bus stop in a high crime area). These ideas are now discussed further with reference to previous research.

There have been some studies into crime and disorder near such public transport facilities. Block and Davis (1996) examined the geographical distribution of street crime in four districts of Chicago, to ascertain whether the area adjacent to rapid transit stations is a focus for street crime or not (as opposed to looking at crime within stations). They found that in the low crime rate areas street robbery was concentrated near (but not immediately outside) rapid transit stations. In the high crime rate areas, although robbery was most prominent on main streets, over the two-year period at least one robbery occurred on every block. They also found that robbery varied temporally, concentrated late at night (11.00 to 12.00 pm, with a peak time of 2.00 am).

Loukaitou-Sideris (1999) looks at the connection between criminal activity at bus stops and environmental factors based on empirical observations, mapping and survey research. Ten high crime bus stops were analysed along with four low crime 'control' stops in Los Angeles. Across the whole system incidents were rare (there were fewer than 5 crimes per 100,000 passengers). They found that the ten high crime bus stops that they examined accounted for 18 percent of the total crimes reported out of 19,650 stops. Although passenger levels at these stops were high, other nearby high patronage stops exhibited little or no crime.

By examining the physical and social context of the surveyed bus stops, they found an abundance of 'negative' environmental factors and a general lack of defensible space at the high crime stops, whereas the four comparative low crime rate stops lacked negative environmental factors and offered better surveillance opportunities. These negative factors (within 300 feet of

a stop) included “liquor stores, bars, check cashing establishments, seedy motels, pawn shops, vacant lots/buildings and adult book stores and movie theatres” (Loukaitou-Sideris 1999: 06). The authors conclude that their empirical research indicates that environmental attributes and site conditions at bus stops do have an impact on crime levels. This finding is supported by Newton (2004b) who examined criminal damage to bus shelters in Merseyside (UK), and found damage was related in a systematic and predictable way to known attributes of a shelter’s location

Liggett et al. (2001) extended the work of Loukaitou-Sideris, to investigate how environmental factors around a bus stop could be used as a predictive rather than an indicative measure, to estimate the likely amount of crime as a result of placing a bus stop at a particular location. Using a series of regression models, they determined a number of environmental predictors of bus stop crime, and found that the most important predictor was location.

Any examination of the public transport needs to consider the transport journey from start point to destination point. The system should be examined in its entirety, and, indeed the holistic approach to the public transport journey advocated by the DETR, the ‘whole journey approach’ is needed to tackle crime on public transport. A transport journey consists of a number of discrete, inter-linked components, and passengers and staff need to feel secure during all aspects of a journey. *“The best priority is a holistic treatment. If one link of the journey is wrong the whole journey may be cancelled or replaced by a car trip”* (DETR 1999: 109). When examining the public transport system from this standpoint, it is possible to distinguish (at least) three possible scenarios in which a crime event can occur. These are:

- i) Walking or transferring between stops on foot (departure point to stop or station, between stops or stations, stop or station to destination point).
- ii) Waiting at boarding or embarking points (at a stop, station or interchange).
- iii) On board a mode of public transport (bus, train, tram or other mode).

The above discussion outlines how public transport systems contain a number of settings, which include the mode of transport (bus, train, tram for example) and the infrastructure (stops, stations and interchanges). There are perhaps two distinct influential environments, the differing external environments the public transport vehicle traverses, and the internal environment of the vehicle itself. These external environments will vary by crime levels, socio-economic characteristics, land use, demographics, and the physical infrastructure (the layout of roads and buildings or the amount of open

space). The internal environment will vary by the design of the vehicle itself. The link between these two environments is provided at the stops, stations and interchanges, which provide the gateway between the internal and external environments, or the entry onto and exit from the system. These entrance and exit points will also vary by the way they are designed, be it the layout of a large station, a single stop, or the entrance to the vehicle itself. These exit and entry points provide the inputs and outputs to the system. There are a number of potential victims of crime on the system, including passengers, staff, and facilities. There are also a number of entry and exit points onto the system for potential offenders, and capable guardians. Thus, examining the nature of crime and disorder on public transport becomes a highly complex process.

APPLYING ENVIRONMENTAL CRIMINOLOGY RATIONALE TO PUBLIC TRANSPORT

Environmental criminology theories (Bottoms and Wiles 1997; and Clarke and Eck 2003) examine how the convergence of a number of factors, is more likely to result in the occurrence of crime. These features include location, environment, the potential opportunity to commit a crime, the absence of capable guardianship, the presence of offenders and targets, and the juxtaposition of all these elements in time and space. Three of the most influential theories of environmental criminology are Routine Activities Theory (Cohen and Felson 1979), the Rational Choice Perspective (Cornish and Clarke 1986), and Crime Pattern Theory (Brantingham and Brantingham 1993).

Routine Activities Theory states that for a criminal event to occur there must be a convergence in time and space of three factors. These are (a) the presence of a motivated offender, (b) the absence of a capable guardian, and (c) the presence of a suitable target (person or object). Whether or not these elements converge or coincide is a product of the routine activities (day-to-day movements) of potential targets and offenders. Public transport journeys may encompass part of the routine activities of offenders, suitable targets (staff, passengers and facilities), and capable guardians (for example, police officers, security staff, CCTV cameras, or members of the public). This is particularly true when considering the whole journey approach to public transport, from destination point to end point (door to door). It is possible that the availability or lack of public transport may actually influence a person’s routine activities. The use of public transport may also be shaped by obligatory (that an individual must undertake) and discretionary (that a person chooses to undertake) routine activities (LeBeau 2002).

‘Rational Choice Perspective’ suggests that offenders will choose their targets and achieve their

goals in a manner that can be explained (Cornish and Clarke 1986). This seeks to explain the way in which crimes are distributed by weighing up the potential cost of a crime (chance of apprehension, cost of journey) against its possible benefits (potential reward, ease to commit). Crime is assumed to be purposive to the offender's needs, and constrained by limits such as time and the availability of information (Felson and Clarke 1998). The offender rationally chooses the situation with the highest net outcome. There is no reason to suggest that an offender would not make a rational choice about committing a crime because they are within the public transport domain, and, indeed, the decisions and choices they make are likely to be influenced by the system itself.

Crime Pattern Theory argues that 'crime is an event that occurs when an individual with some criminal readiness level encounters a suitable target in a situation sufficient to activate that readiness potential' (Brantingham and Brantingham 1993: 266). This approach to understanding crime contends that crimes are patterned, but these patterns are only discernible when crimes are viewed as aetiologically complex, occurring within and as a result of a multifaceted environment (Eck and Weisburd 1995). Crime is best viewed as an action that occurs within a situation at a site on a changeable backcloth. This environmental backcloth includes social, cultural, legal, temporal, spatial, and physical infrastructure characteristics (Brantingham and Brantingham 1993). When broken down the model described above is complex because the backcloth, site, situation, an individual's criminal readiness and the distribution of targets are all required to be examined coincidentally with each other in order to explain individual crime events.

The three principal components of Crime Pattern Theory are nodes, paths and edges (Brantingham and Brantingham 1981) and these appear to be particularly transferable to the public transport arena (Felson et al. 1996). The idea of personal activity nodes closely resembles routine activities, and refers to a number of behaviour settings (slices of time and place where certain activity occurs) that alter with time. These nodes are linked by paths, which represent journeys between different activity nodes. Edges define the boundaries around nodes and paths. Certain crimes may occur at these edges, where people who are not familiar with each other meet (for example, racist attacks and robberies). Public transport journeys may represent such paths, and facilitate the movement of persons between some of the activity nodes. These paths on the public transport system are separated by edges, defining by the outer extents of the system, and regulated by the various inputs and outputs to the system (stops, stations and interchanges).

A final concept that has been previously applied to public transport systems is the idea of crime generators and crime attractors (Brantingham and Brantingham 1995). The authors suggest that public transport stations may be crime generators, crime attractors or fear generators. Transport stations contain a number of people congregated together and this may produce the opportunity for a crime to occur (a crime generator). At certain times of the day these crowds and the characteristics they exhibit (for example, commuters during rush hour) may produce suitable conditions for a particular type of crime (for example, attract offenders who believe there is opportunity to pick-pocket), and hence stations may act as a crime attractor. Fear of crime can be generated in number of ways, especially if the environment appears unclean, uncared for, not well lit or poorly supervised (the Broken Windows Theory, after Wilson and Kelling 1982).

This discussion suggests that all these theories could be used to explain crime on public transport. From this a number of potential directions for future research can be identified. One avenue for exploration is to examine whether public transport systems act as crime generators or crime attractors, or both (which Brantingham and Brantingham (1995), begin to explore). A second possible study is to investigate if certain paths on the public transport network facilitate crime. Belanger (1997) starts to investigate this, by examining how far offenders traveled from their place of residence to the place where they committed subway crime. There appears to be scope to utilise environmental criminology theories as an explanatory focus for crime events on public transport, and the following sections examine the methodological approaches necessary for this, to ascertain the validity of such an approach.

STATIC AND NON-STATIC CRIME EVENTS

Earlier in this paper three situations were identified where a crime could occur, when using the holistic approach to public transport journeys. These include walking to, from and between stops, waiting at a stop, and travelling on a moving vehicle. From an environmental perspective, these can be described respectively as the following three different (but interlinked) situations:

- i) The *walking* environment
- ii) The *waiting* environment
- iii) The *en-route* environment

When considering a crime event in simple terms, as being something that happens (Eck and Weisburd 1995), it may be argued that the above circumstances describe two types of crime events. These situations describe a mixture of '*static*' and '*non-static*' events, in terms of where and when the crime event actually

occurred. The first two situations primarily describe a static crime event. For the purposes of this paper static crime events refer to a crime occurring at an exact place, that can theoretically be pin pointed to a specific location (x,y co-ordinate). An example of this would be assault at a bus stop or train station. The second possible scenario, however, implies the crime to be moving and this can be described as a non-static crime event. When a crime occurs on a moving mode of transport (bus, tram, or train for example) it is difficult to pin point the exact location where the crime event occurred, as the crime happened on a moving vehicle.

Non-static crime events may have more than a single location, and have a start point (the place the crime started) and an end point (when the crime finished). These two locations may be different, even if the crime event only lasted for a short duration (for example over a thirty second time frame). An example of this may be an assault that occurs on a moving vehicle.

It is acknowledged that in certain circumstances the distinction between static and non-static crime events is less clear. It could be contended that the walking environment implies movement and therefore should be viewed as non-static. When a crime event occurs in the walking environment, however, it is likely that the target is stationary at the time of the crime event, or movement is over a very short distance, perhaps a few feet, and this location can be recorded as static (x,y location). The speed of travel here is an important factor, as over the same time period that the pedestrian moves a few feet, a bus or train may move several hundred metres.

Additionally, when a moving vehicle is stationary (perhaps at lights or at a stop), it could be argued that this is static. Whether a crime here is recorded as static or non-static would depend on a number of factors. These include; where the crime happened (did the crime happen only when the vehicle was stationary, or include some movement of the vehicle before and or after the stop); the duration of the crime; the speed of movement; the distance travelled; and whether the event can be recorded at an exact location (x,y co-ordinate) or between two points and times.

Finally, a missile (any item that could be thrown at a vehicle including rocks, stones, bricks, and eggs for example) projected at a vehicle implies the object has been thrown from a static location, onto a vehicle that is moving (static to non-static). This situation here is unique as it represents one of the few interactions between the internal (inside a vehicle) and external (outside of a vehicle) environments of the transport system that does not necessarily occur at a station, stop or interchange. At the point of impact, the crime event could be pinpointed as static.

It can be argued that any crime event could take place over a time period and moving space, for example

a person gets knocked down, dragged into a car and driven away, or a shop is 'ram-raided', (when a car, usually stolen, is driven through a shop front) property is stolen from the shop, and driven away (usually in another car). However in these situations the crime events can be split into three separate acts, each with three separate locations, whereas an assault that occurs on a moving bus or train is a single continuous act with a moving space and time. The difficulty faced is that no single precise location or time can be provided for the crime event (the assault).

These static and non-static ideas may apply not only to the crime event, but also to its environmental backcloth. The movement of this backcloth may influence the situational factors that converge in time and space, and result in crime events (both static and non-static). How is the convergence of these situational factors influenced by non-static situations? Here the fundamental question arises: can the existing theories of environmental criminology that are largely focussed on static events be applied or adapted to explain crime and disorder on public transport? When examining this further, questions that arise include; are the existing theories limited to the extent that they can't be applied to public transport; can they be adapted; or do new theories need to be developed to explain crime and disorder on public transport?

THE ANALYSIS OF CRIME EVENTS

Environmental criminology studies have primarily considered 'static' crime events. These events have two key attributes, a space or place, and a time. Numerous examples exist of the analysis of crime events outside the public transport arena, including studies into domestic and commercial burglary, assault, theft, robbery, car crime, domestic violence, racial harassment, criminal damage, arson, and juvenile disturbances (Clarke 1997; Goldsmith et al. 2000; Hirschfield and Bowers 2001; and Ratcliffe 2002). The common feature of all this research is that the crime event can be located at an exact place, by a geographical co-ordinate (x,y), at a point in time (t).

As an extension to this, research by Ratcliffe (2002) developed the idea of aoristic crime analysis. This considers that a crime may occur at a single place, but it is difficult to define the exact time of this crime event. In this analysis burglary incidents are examined, which, by their nature, happen without the presence of a person to report the time of the incident. They can be captured between the time a person left a property, and the time someone has discovered the incident. Thus, the crime occurs at a single location (x,y), but occurs between two time points (t_1 and t_2). These characteristics could also apply to any crime event that occurs at a single point and have a start and end time, between times t_1 and t_2 , that differ significantly.

Furthermore, there has been research that examines an offenders journey to crime (Wiles and Costello, 2000), from the point an offender travelled (x_1, y_1) at time t_1 to the point the offender committed the crime (x_2, y_2) at time t_2 . When the actual crime is committed, the crime event itself is at (x_2, y_2) at time t_2 . An alternative to this it to examine the relationship between where a crime occurs and property is recovered, for example theft of a vehicle. In this example the theft of the vehicle would be at point and time (x_1, y_1, t_1) and the recovery of the vehicle at point and time (x_2, y_2, t_2) , but the actual crime event itself would be (x_1, y_1, t_1) .

Crimes do not occur randomly or uniformly over time or space, and the purpose of examining the patterns and distributions of crime events and the environment where they occur, is to seek to explain the patterned non-uniformity or non-randomness that real crime events exhibit. The technological developments in Geographical Information Systems (GIS) and the growth of crime mapping and crime analysis (Getis et al., 2000; Hirschfield and Bowers 2001) have led to the development of a number of tools for the spatial, temporal, and spatio-temporal analysis of crime patterns. Some of these techniques are highlighted in later sections of this paper.

Spatial analysis techniques require information on the location of the crime event. The term spatial analysis covers a wide area, but can be defined as “*the assemblage of analytical techniques and models in which a clear association is maintained between quantitative data and the spatial co-ordinates which locate them*” (Chorley 1972, after Wise and Haining 1991, 3.24.3). A variety of clustering algorithms have been used to examine the spatial distribution of crimes (Anselin et al., 2000), including neighbourhood hierarchical ellipses, kernel density interpolation, LISA (Local Indicators of Spatial Association), K-Means clustering, STAC (spatial and temporal analysis of crime), Voronoi analysis, GAM (Geographical Analysis Machine), CrimeStat, and SCAS (Spatial Crime Analysis System).

In addition to examining the location of crimes, it is useful to examine the environmental characteristics of the area where crimes occur, to add further explanations to the occurrence of crime. Such features include land use, the physical infrastructure of the area (the physical layout of buildings), socio-economic, and demographic information. Hillier and Shu (2000) discuss how the layout of urban space may influence crime levels. In order to explore this further, micro level data is required, at a fine scale (individual level) on both the exact location of crime, and its environmental characteristics.

It is important to include data not only on the spatial location of a crime, but also non-spatial information that can provide valuable insights into the occurrence of a

crime. An example of this is the concentrations of crime evident on public transport, such as Pealstein and Wachs’ findings (1982) that only 18 out of 233 bus routes had a serious crime incident, or the results of Loukaitou-Sideris research (1999) that found 10 high bus stops (out of almost 20,000 stops) accounted for 18% of crime incidents at bus stops. Combining this with the temporal concentrations of crime evident in these studies and the findings of Levine et al. (1986) should enable highly effective targeting of resources. Furthermore, this generates questions such as why is crime clustered at these routes and stops, and why do other routes and stops experience lower levels of crime?

It is important to include criminological theory when performing any crime analysis or crime mapping, as the spatial element of a crime on its own has a limited usefulness for future crime prevention. Pease (2001) likens this to knowledge of a footballers position on a pitch, its meaning and usefulness is informative only when we have knowledge of the laws and tactics of the game. It is essential to incorporate environmental criminology theory within any spatial, temporal or other quantitative analysis of crime patterns. The following section explores whether the traditional analysis methods embodied within current environmental criminology theories can be applied or adapted to analyse crime events on public transport.

Methods for Analysing Crime Events on Public Transport

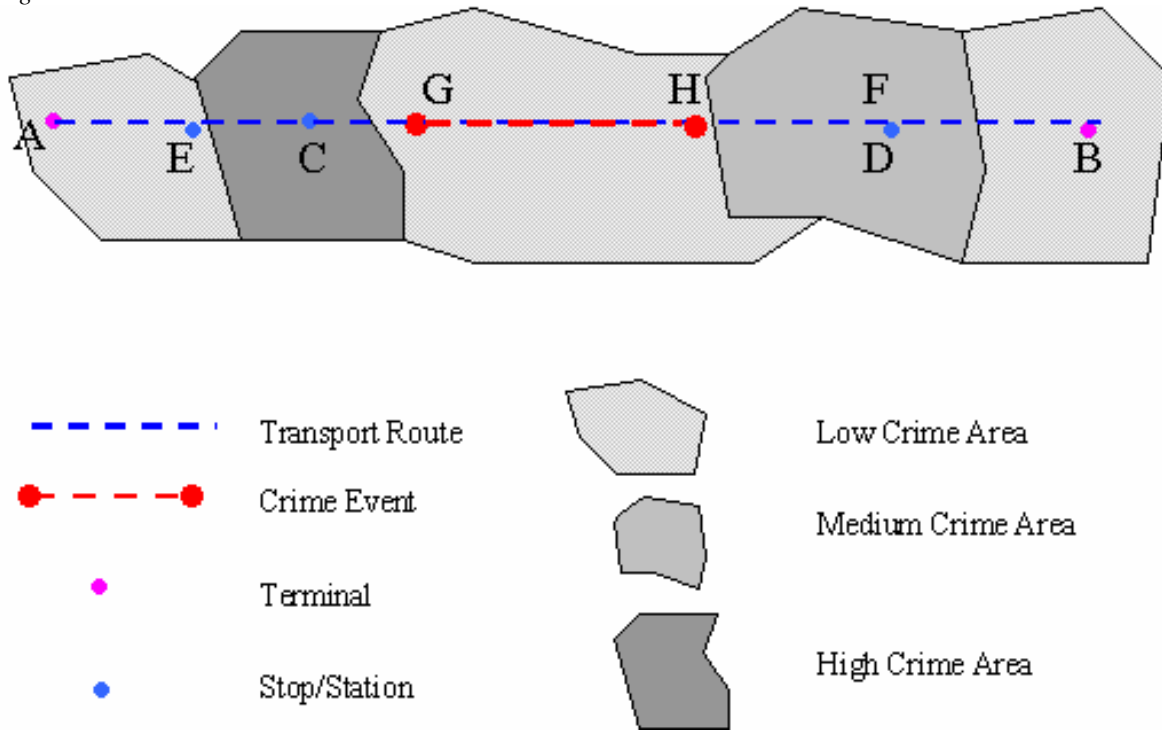
Crime events on public transport, as described earlier, may occur within the waiting, walking, and en-route environments of the whole journey. Thus, these ‘static’ and ‘non-static’ crime events can be translated into three types of situations using the various crime analysis techniques described previously. Crimes may occur in the following situations:

- i. At x_1, y_1, t_1 (for example an assault at a bus stop)
- ii. Between x_1, y_1, t_1 and x_1, y_1, t_2 (for example criminal damage to a bus shelter)
- iii. Between x_1, y_1, t_1 and x_2, y_2, t_2 (for example assault on a moving vehicle)

The first two situations above describe a ‘static’ crime event, and the latter a ‘non-static’ crime event. In situation (i) for example, the place where the crime event occurred (x_1, y_1) and the time of the event (t_1) are both known. In situation (ii) the location of the incident is also known (x_1, y_1) but the precise time it occurred is not known, only that it happened sometime between time t_1 and t_2 . As the crime event happens at a unique location (x_1, y_1) it can be termed a static crime event.

In situation (iii) the crime event has a starting point and time, and end point and time that are different. There are a number of considerations here that could be

Figure 2. *Non-Static Crime Events.*



used to capture information about this non-static crime, and these are depicted in Figure 2.

- The departure and termination points of the vehicle (points A and B on Figure 2 respectively).
- The environments through which the vehicle has traversed before the crime event occurred.
- The points where the vehicle stops along the route.
- The point the offender boards/alights the vehicle (points C and D on Figure 2 respectively).
- The point the victim (if a person) boards/alights the vehicle (points E and F on Figure 2 respectively).

The point where the crime begins (trigger point or start point G on Figure 2) and the point the crime ends (point H on Figure 2).

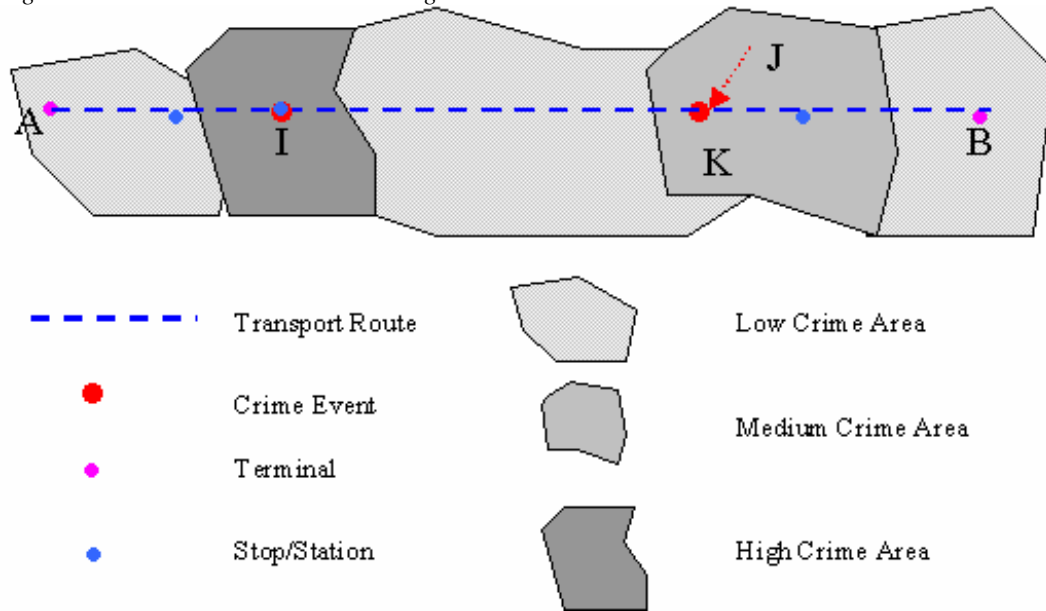
For a crime that occurs between two points, a question arises as to whether to capture the two points that demarcate the location of the crime event, or further detail such as the start and end points of the journey, and where the offender and victim boarded the vehicle. During its journey, the external environment that a vehicle traverses will vary. The characteristics of the areas surrounding stops will influence who is boarding and alighting the vehicle, and this influences the on board environment in terms of who is on the vehicle (although the actual design of the on board environment does not change). The demarcation of the crime event could be between two points where the crime occurred (G and H on Figure 2 respectively), or between two

stops (C and D on Figure 2 respectively). The crime event may also span several stops if a moving vehicle does not stop at certain stops whilst a crime is happening. In the example of assault on a moving vehicle, the start point would be where the vehicle was when the assault commenced (point G), but this does not distinguish where the offender (point C) or the victim (point E) actually entered the vehicle, nor the last point they could have boarded the vehicle (point E), nor why they first committed the crime where they did (trigger point G on Figure 2).

For some situations the crime might occur when the vehicle is stationary. Here it might be possible to consider the crime as a static crime event (point I in Figure 3), for example if the crime event is a single incident without a start and end point, or if the vehicle is stationary at the time of the incident.

Another potential scenario is that an object is thrown or missile is projected (from a static location) onto a travelling vehicle (a moving entity). Here, it is suggested it is more important to capture information about where the missile is thrown from (point J on Figure 3) and the position of the vehicle upon impact (point K on Figure 3), as the route the vehicle has traversed previously is unlikely to have any influence on the position the missile was thrown from. In this situation the trigger point would be where the missile was thrown from, but if the vehicle did not pass this point, or no missile were available, the crime would not

Figure 3. Static Crime Events on Moving Vehicles.



have occurred. This is unique in that it represents one of the few situations where the internal and external environments converge outside a stop or station.

There are added difficulties in locating public transport crime. For some crimes (for example graffiti or damage to a vehicle) the incident may not be discovered until the end of the journey, or when the driver returns the vehicle to the depot, and thus the crime could have happened any time between when the vehicle was last checked and the time the damage was discovered, along the route (or routes) it has travelled through between these times.

This mixture of static and non-static crime events in the public transport environment, presents a situation that is perhaps unique for the analysis of crime events. The question posed here is how to apply the traditional methods of crime analysis to both static and non-static crime events.

Analysing Static Crime Events

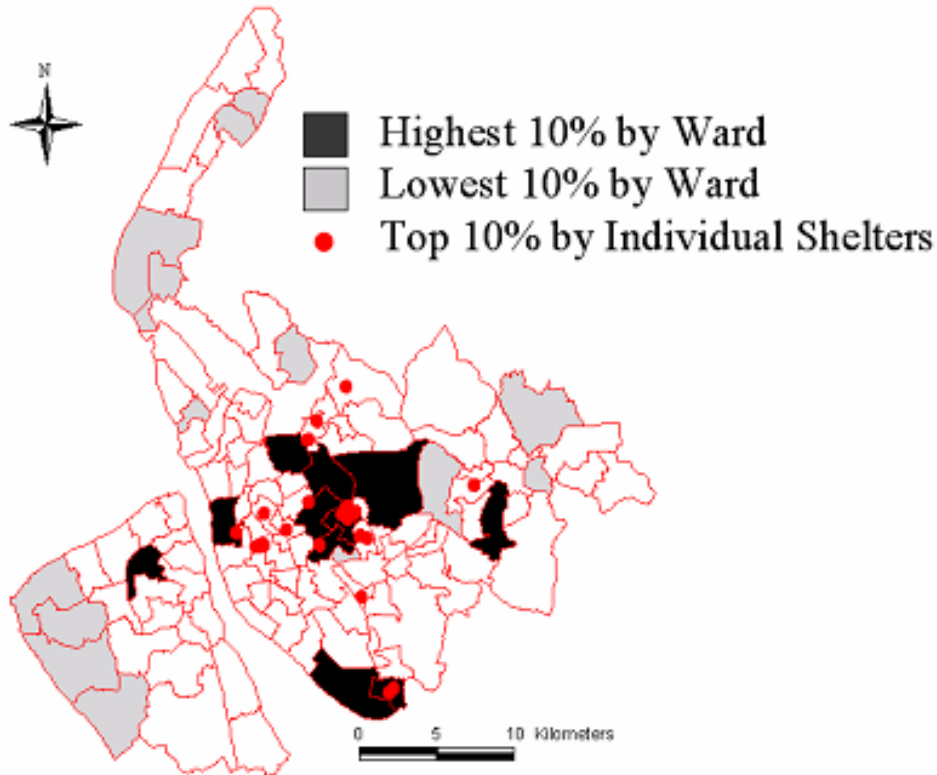
Earlier in this paper, a number of clustering algorithms and spatial analysis techniques used to examine patterns of crime were described, and these have been applied in a number of studies outside the public transport arena. These methods can also be readily applied to examine the spatial patterns of static crime events on public transport. This is because these static crimes on public transport have a spatial location, or geographic coordinate (x,y), of where the crime event occurred. An example of the spatial analysis of static public transport crime events is research into bus shelter damage (Newton 2004b).

One of the more common approaches used to examine static events is hot spot analysis. A hot spot can be described as a “geographical area of higher than average crime and or disorder. It is an area of crime or disorder concentration relative to the distribution of crime and disorder across the whole region of interest (e.g. ward, district, or county). Hotspots are areas of clusters of crime or disorder that can exist at different scales” (Chainey 2002). Whilst it is acknowledged that hot spots in an area can vary by the time of day, for example hot spots in an area at 12.00 midday may be very different to the hot spots in the same area at 9.00 pm, these incidents here can still be considered ‘static’ crime events, examined at two different times of the day.

The spatial analysis of crime data (Anselin et al., 2000) uses either information on the unique location of individual crimes (disaggregate data with an x,y point), or aggregated data (that combines individual point data into larger areal units). These two techniques have been combined and displayed on a single map in Figure 4, which examines incidents of criminal damage to bus shelters in Merseyside (UK) over a one-year period.

The analysis of individual (disaggregate) point data is demonstrated through the use of the red circles in Figure 4. These circles represent the top 10% of individually damaged shelters in Merseyside over the one-year period. These individual shelters could also have been analysed statistically using the various clustering algorithms described earlier such as kernel density interpolation or Nearest Neighbour Hierarchical (NNH) analysis, to identify the hot spots of shelter

Figure 4. *Bus Shelter Damage on Merseyside, North West England in 2002.*



damage. The advantage of this type of analysis is that crimes are not aggregated into pre-defined areas, thus patterns identified may be more tangible to the real world, since offenders committing crimes are not constrained by administrative or other boundaries (Hirschfield and Bowers 2001).

In Figure 4 the wards from the 1991 Census of Population are also portrayed. An example of using aggregated data to analyse the patterns of crime is the use of the light and dark shaded wards. In each ward the number of times an individual bus shelter is damaged can be counted (using disaggregate data). This information can be merged and aggregated for each ward. The wards with the highest (dark shading) and lowest (light shading) 10% of incidents of bus shelter damage in Merseyside are highlighted in Figure 4. It is noticeable that a preventive measure aimed at reducing crime at the top 10% of individual shelters that were damaged would focus on different shelters to a reduction measure aimed at tackling the 10% of wards that experienced the most shelter damage.

These individual incidents of shelter damage could have been aggregated into a number of other areal units, such as census areas, police beats, social service areas, or other administrative boundaries. The user may also create these areas, around housing estates or to map socially perceived neighbourhoods or communities for

example. A number of spatial autocorrelation techniques exist for the statistical analysis of aggregated data (see Anselin et al. 2000). The advantages of using aggregated information is that data sets with coterminous boundaries can be cross-referenced, for example comparing crime levels aggregated to census wards with the socio-economic characteristics of those wards. The disadvantages of this are that within these areas there may be localised pockets of high or low crime areas that are not apparent at the aggregated level (Hirschfield and Bowers 2001). Furthermore, such analyses are prone to errors that arise due to the Modifiable Areal Unit Problem (Openshaw and Taylor 1981) and the Ecological Fallacy (Brown 1991).

Analysing Non-Static Crime Events

The traditional spatial analysis techniques described above cannot readily be applied to 'non-static' crime events, due to the difficulties in locating a moving crime event. It is possible that this requires alternative techniques to be developed. However, it is contended here that non-static crime events do contain information on the location of the crime incidents. It is possible to demarcate a crime between two points (x_1, y_1 and x_2, y_2) and two times (t_1, t_2) as a single linear event at a single snapshot of time. Thus, instead of applying analysis techniques to points or areas (as with the traditional

approaches), spatial analysis methods can be performed on these linear routes or lines. Thus, for the purposes of analysis these non-static crime events can also be treated as static.

Two possible methods to analyse these linear crime events are depicted in Figures 5 and 6. It is likely that alternative and perhaps better spatial analysis techniques can be developed around the idea of a linear crime event, but as a starting point this discussion focuses on how the public transport route can be delineated into smaller components or sections, to examine the differences between sections of a route with low, medium and high levels of crime.

In Figure 5 the route has been subdivided into a number of sections, or areas. These could be segmented by administrative boundaries such as census output areas, or be created by the user. For example stops and stations along the route could be used to delineate route segments. These stops would demarcate the last point an offender or victim could have boarded a vehicle before the crime occurred, although the actual boarding points may have been many stops earlier. However, this would enable crime events on public transport to be examined for a number of route segments (between stops and stations), and, for each segment, to be cross-referenced with the social and physical characteristics of the surrounding areas or environments. It would also enable a profile to be developed of the area a route has traversed, before a crime event occurs.

An alternative technique is to perform buffer analysis, around either linear crime events (Figure 6), or to create buffers around segments of routes. This can be achieved by creating concentric buffers around route segments or linear crime events, at equal distances. For example a series of concentric 50m buffer zones could

be created around linear crime events, the first 0-50m, the second 50-100m, the third 100-150m and so forth. Within each of these buffer areas, characteristics of these areas could be compared with the amount of crime occurring in that linear event.

From this the relationships between characteristics of surrounding environment and levels of public transport crime could subsequently be examined. If particular characteristics are found to influence crime levels on the route, perhaps a relationship exists between areas of high crime in general and transport route segments with high levels of crime for example, then the influence of this by proximity to the route could also be examined. Theoretically those buffer zones nearest to the route would have a greater influence on the level of crime experienced than the zones further away from the route. In addition to the influence of surrounding crime levels, this technique could also be utilised to examine the relationship between crime on the public transport route and other features of the physical and social environment. It is acknowledged that there may be difficulties in obtaining micro level data on the environmental characteristics of these individual buffers zones, but the development of urban mapping systems (such as OS MasterMap in the UK) with this type of disaggregate information, should better facilitate such an approach.

These two analysis techniques are illustrated here to demonstrate the difficulties faced in analysing crime on public transport. It may be necessary that alternative and more appropriate techniques need to be developed to analyse linear patterns of crime. The difficulties in collecting data on the location of a moving crime event, in addition to the limited information collected about crime on public transport in general (as described earlier

Figure 5. Analysis of Non-Static Crimes by Route Section

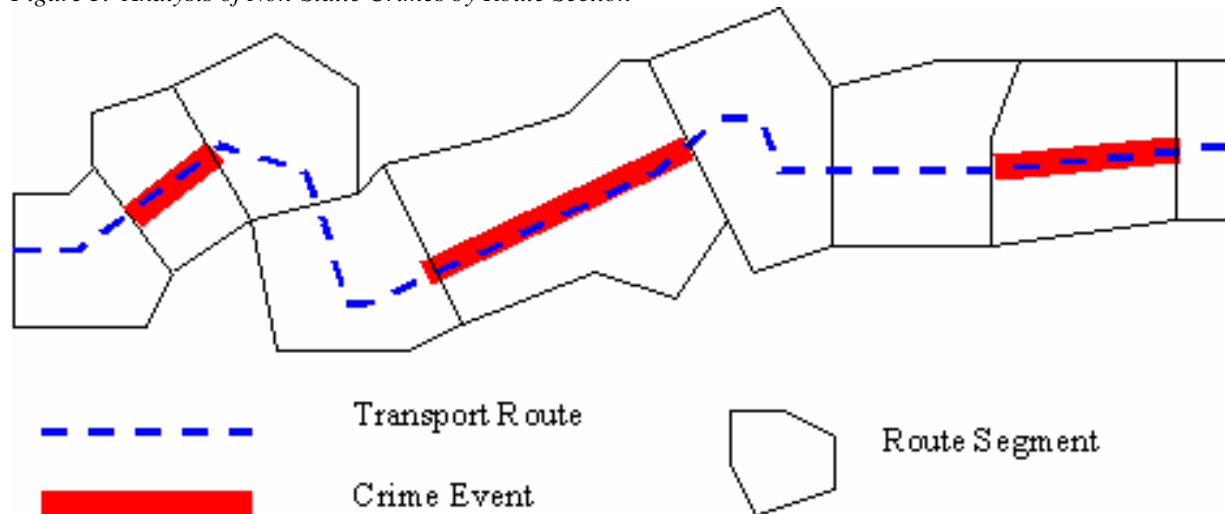
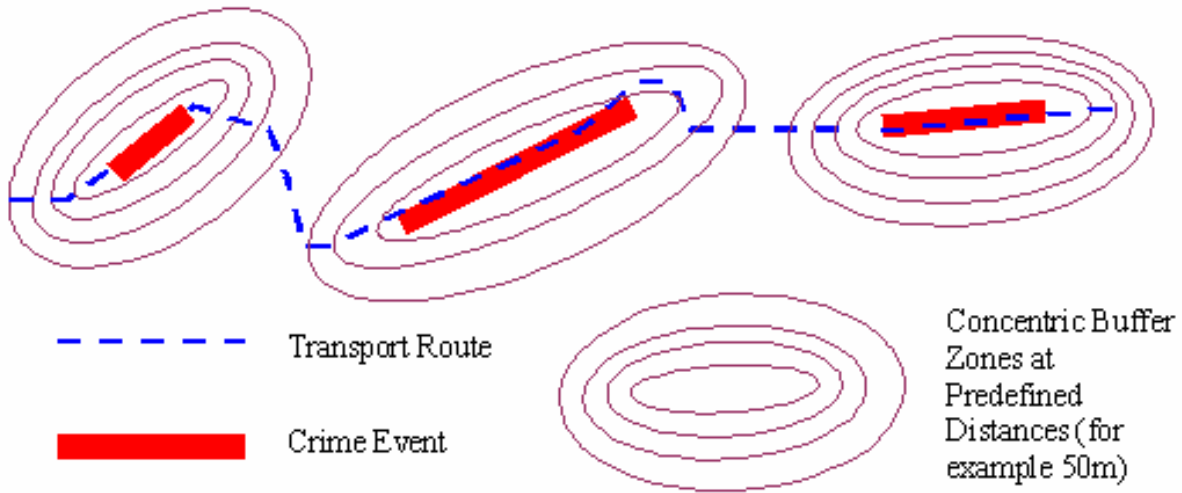


Figure 6. Analysis on Non-Static Crimes by Buffer Analysis.



in this paper), are perhaps the two primary reasons for the paucity of studies evident in this area.

Accurately Reporting a Crimes Location on Public Transport

The analysis techniques described previously require the location of a crime event on public transport to be demarcated at a precise location, which may be at an individual location and time (x_1, y_1, t_1) or between two points and times (x_1, y_1, t_1) and (x_2, y_2, t_2) . This will allow a public transport route to be divided into smaller subsections, to examine where and when crime occurs along a route and the potential reasons for this. This is depicted in Figure 7. However, careful attention should be afforded to the methods used to report the location of crime events on public transport.

The method by which a crime event is captured is important, as it will not only heavily influence what subsequent analysis can be performed, but can actually determine which analytical techniques can be applied. A simple example of this is when a crime is located by the general area where it occurs, for example a police beat or census area, and not by its exact geographical position (x, y) co-ordinate. This would enable spatial analysis of crime patterns by area (for example by police beat), but spatial analysis of individual crime points would not be possible.

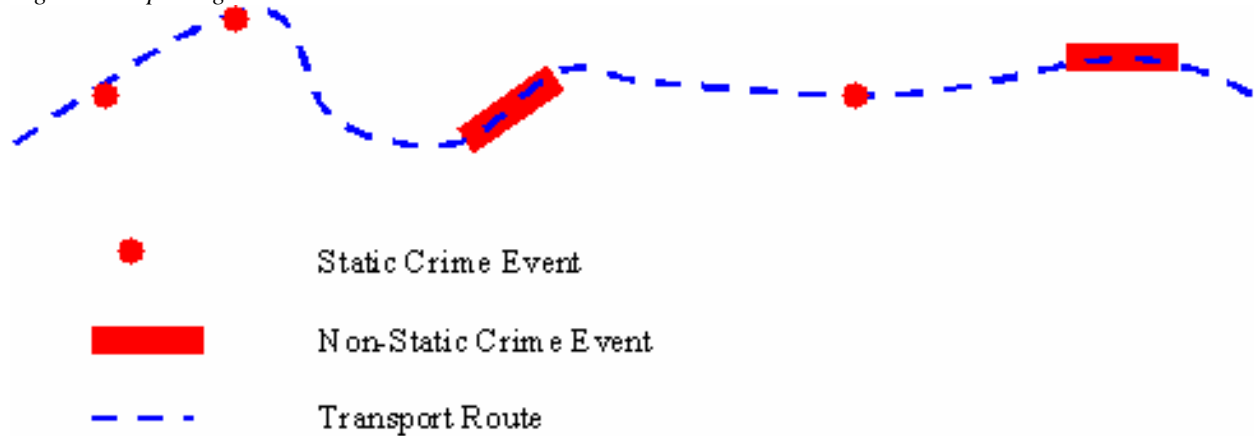
The geographical position of crime can be reported in a number of ways, and in the UK the Ordnance Survey's National Grid is commonly used to produce precise x and y co-ordinates. However, inaccuracies in the location of crime events evident in current crime data systems (Hirschfield and Bowers 2001), focussed primarily on capturing static crime events, are likely to be magnified when locating non-static crimes.

When a crime occurs on a moving vehicle, it is very difficult for a driver or ticket officer to accurately report its location, and then for this to be accurately transferred into a computer database. The use of a road name, which may be several miles long, does not demarcate precisely where crimes occur. On rail tracks it is often difficult to find a point of reference to locate where a vehicle is. Road intersections and nearby landmarks may help to locate crime incidents more precisely, but what is desirable is a geographical co-ordinate, the vehicles route (by name or number), and the direction of travel.

One potential tool to aid the accurate location of crime is the use of Global Positioning Systems (GPS). Bus operators in the UK are developing GPS tools to automate their revenue collection, and to develop electronic timetable displays at stops that use real time. This time is based on where the bus actually is in relation to the stop, and not when it is likely to arrive based on timetable information. GPS devices may be handheld or attached to a vehicle, but would need to be manually activated to indicate when a crime starts, and perhaps also finishes. The police, fire and ambulance service are at the forefront of developing more sophisticated methods of accurately reporting where their incidents occur, particularly to ensure a rapid response to emergency calls.

Newton and Hirschfield (2004) highlight the inconsistencies in current methods used to capture crime data on public transport in the UK in their examination of crime on buses in three case study areas. They found that each study area recorded the location of crime in a different fashion. In one area only the route number was used, in another area the crime was located by the nearest bus stop (x, y) position) although the actual bus

Figure 7. Capturing Static and Non-Static Crime Events.



route was not recorded. In the final area, both the geographical position of the actual crime (x,y) and bus route number were recorded. The analysis that could be performed was limited by the way the data was recorded, and for each of the case study areas it was necessary to employ a different methodology. Interestingly however, these three different approaches all yielded the same finding, that bus crime was positively correlated with general crime levels in the surrounding area.

The limitation of recording only the bus route with no precise geographical location of where the crime occurred is that, although high crime bus routes were shown to pass through high crime areas, it was not possible to test whether the risk of crimes on buses was greatest when the bus was in high crime areas. The limitation of recording bus crime by nearest stop and not by route number is twofold. Firstly the crimes location is slightly distorted, and secondly although the location of high bus crime incidents corresponded with high crime areas, there was no information on where the bus had previously traversed. This is important as the characteristics of the areas surrounding these previous stops, could influence who boards and alights the bus (potential offenders and targets).

There are a number of ways by which crime events on public transport can be located, but it is suggested that the following information is essential.

For static crimes:

- (i) the point at which the crime occurs (for example x_1,y_1)
- (ii) the route name or number (if applicable)
- (iii) the direction of the vehicle (start and destination point, if applicable).

For non-static crimes:

- (i) the points and times the crime started (x_1,y_1,t_1) and finished (x_2,y_2,t_2) and or
- (i) the last stop before the crime started and the first stop after it finished
- (ii) the route name or number
- (iii) the direction of travel (start and destination point)

This information will demarcate the actual crime offence in terms of its location, but will not define where the offender or victim boarded a vehicle. Perhaps the most appropriate mechanism for reporting the location of non-static incidents warrants further research, particularly as this is likely to impact upon the analysis that can be performed.

CONCLUSION

This paper has highlighted the complexity involved in examining crime and disorder on public transport and the difficulties this poses when attempting to analyse such crime events. The public transport environment itself has been shown to be a multifaceted arena, with a number of settings, and a range of potential offenders, victims and guardians. These settings include different modes of vehicle (including buses, trains, trams and other forms of transport), and facilities such as stations, stops and interchanges. Moreover, the external and internal characteristics of these environments need to be carefully considered. The vehicles will traverse through a range of different external environments, and in addition to this, will have their own internal environment unique to that vehicle. This may vary between two different designs of buses, and between a bus and a train for example. The design of the stops, stations, and interchanges themselves may also influence crime on the system. These stops, stations, and interchanges act as the gateway between the internal and external environments, and control the input and

output of potential victims, offenders, and guardians onto the system.

When the holistic approach to public transport is considered, which is necessary due to the interlinked nature of public transport, three scenarios exist whereby a crime event may occur, the waiting, the walking, and the en-route environments. These can be considered as static and non-static crime events, as the crime may occur; at time and place x_1, y_1, t_1 ; at time and place x_1, y_1 and between times t_1 and t_2 ; or between places and times x_1, y_1, t_1 and x_2, y_2, t_2 . Current theories of environmental criminology focus on the first two situations (static crime events), but do not consider the latter of these, the non-static crime events.

As a result of this, the techniques developed to analyse crimes have centred upon analysing points (disaggregate data) and areas (aggregate data). These traditional crime analysis methods can be applied to static crime events on public transport. What has not been considered is how to analyse the non-static crime events. It is contended, for the purposes of crime analysis, it is possible to capture non-static crime events as static. By representing the crime event in a linear format, the route a vehicle travels between x_1, y_1 and x_2, y_2 and times t_1 and t_2 , depicts a static crime event (a line) at a single snapshot in time. Thus, it could be argued that the terms static and non-static crime events are arbitrary definitions, and, for the purposes of analysis, all public transport crime can be captured as static. The location of these events might be a single point, a single place or area, or a line between two points. It is suggested that the traditional theories of environmental criminology are very applicable to public transport systems, and the difficulties that are faced are more analytical than theoretical.

The techniques available to analyse linear patterns of crime are perhaps underdeveloped, and it is suggested efforts are needed to address this. There are a number of potential benefits here, to investigate not only crime on public transport routes, but also crime across corridors in general. This may have particular relevance to crime pattern theory, and to the idea of nodes and paths. The developments in the field of GIS, particularly in network analysis, alongside the collection of more data on the location of crime on public transport, would enable this to be explored further. This may be important in furthering our understanding of how the public transport system may act as a crime generator or crime attractor, and the implications this has for crime prevention. On public transport, the influences of the external environment a vehicle traverses, and the internal environment of that route, need to be further explored to understand the complexities of the public transport system. In addition to this, the links between these two environments, the internal and external environments, provided by stops,

interchanges, and stations, is perhaps a key area for future research.

This paper has highlighted that the external environment a public transport vehicle traverses can influence the level of crime experienced. This was shown to be influential on both the level of crime on buses, and at bus stops. This may have implications for situational crime prevention measures, as altering some aspect of this environment could potentially reduce crime on the system. However, a greater understanding of the factors that influence levels of crime on public transport is required, in order to select appropriate reduction measures.

This paper has highlighted some of the difficulties faced when persuading passengers and staff to report public transport crime, and in demonstrating to operators the need to collect such information, which has contributed to the limited availability of public transport crime data. It is suggested that in addition to this, the difficulties in precisely locating the location of crime on a moving vehicle, and the limited knowledge of how to analyse such information, are some of the primary reasons behind the paucity of research in this area.

The importance of accurately locating a crime event was highlighted, because it has a direct influence on the techniques and methods that can be applied to examine the prevalence and distribution of this crime. Indeed, as the accuracy of data on the location of a crime event decreases, increased limitations are placed in the choice of available analysis techniques, and the potential for error in analysis also increases. The growth of available and accurate data on crime on public transport currently underway in the UK, combined with the increased awareness of some of the issues discussed above, will favour more empirical testing of these ideas, and the development of improved analysis techniques to examine crime on public transport.

ENDNOTES

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ABOUT THE AUTHOR

Andrew D Newton works with the Applied Criminology Group at the University of Huddersfield as a research fellow. He received his PhD from the University of Liverpool in 2004, and prior to this attained a BSc in geography (Sheffield), and an MSc in GIS (Edinburgh). His research interests include environmental criminology, the geography of crime, GIS, spatial and temporal crime mapping and analysis, quantitative and qualitative analysis of crime prevention, policy evaluation, crime and disorder on public transport, crime and youths, alcohol related crime, corridors of crime, and crime and technology.

Contact Information: Andrew Newton can be reached at: Research Fellow, The Applied Criminology Group, Department of Behavioural Sciences, R1/07 The Ramsden Building, University of Huddersfield, Queensgate, Huddersfield HD1 3DH, email: a.d.newton@hud.ac.uk