DEVELOPMENT AND IMPLEMENTATION OF A VEHICLE-PEDESTRIAN CONFLICTS ANALYSIS METHOD: ADAPTATION OF A VEHICLE-VEHICLE TECHNIQUE

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ABSTRACT

This paper examines the development, use and evaluation of a new traffic conflicts technique specifically addressing pedestrian-vehicle conflicts, with the intention of being applicable to shared space environments. The method is based on an existing well-established and widely used vehicle-vehicle conflict technique but is adapted so as to consider the movement of pedestrians, which differs significantly from that of vehicles. The new method is then implemented on the Exhibition Road site of West London with the use of video data collected from locations with a potentially high concentration of vehicle-pedestrian conflicts and the results of the analysis are presented. Finally, the results are compared against those from other conflicts techniques and also against accident data so as to assess not only the accuracy but also the functionality of the new technique.

1 INTRODUCTION

Road safety has been a major concern since the introduction of motorised vehicles, and remains so, as many people are involved in road accidents every day. Many accidents involve pedestrians, who, being more vulnerable, face a greater risk of suffering injury or death. The traditional approach to protecting pedestrians has been the segregation of pedestrians and vehicular traffic, which, dating back at least to the work of Le Corbusier in the 1930's, relied upon the design and implementation of structures including pedestrian subways and bridges, pedestrianised areas, as well as guardrails and walls separating pedestrian pathways from the road, which in turn was reserved for vehicles. The concept is set out most lucidly in Buchanan's 'Traffic in Towns' report (1), which has served as a street design manual in the UK for many decades.

However, in recent years there has been a trend of moving away from segregation, driven by developments in architecture and urban planning. Segregation has been deemed by some undesirable for urban environments due to its perception as resulting in "the domination of vehicular traffic and associated noise and air pollution alongside street clutter and ugly surroundings" (2). Street design has gradually shifted towards the concept of integration and traffic calming as a means of creating a nicer environment. Early examples include the 'woonerf' and 'home zone' principles for residential areas in the Netherlands and the UK respectively; more recent examples, however, are not confined to residential environments and follow the so-called shared space concept as firstly introduced by Hans Monderman in the Netherlands, which is based on the idea of vehicles and pedestrians sharing a single surface without the clutter of street furniture, signage, delineation or kerbs found in contemporary urban environments (3-7).

Besides the urban planning and aesthetic advantages, it has been suggested that the shared space concept also positively contributes to the improvement of traffic efficiency and road safety, mainly due to the introduction of ambiguity which makes both drivers and pedestrians more vigilant (4,5). From a traffic engineering perspective this is a paradox since shared space introduces vehicle-pedestrian conflicts, which might be expected to lead to more accidents and hence a worse safety record. However, as opposed to engineering out conflicts, the shared space concept engineers them in, with the intention of reducing their severity. This raises the issue of how to measure conflicts and grade them with regard to severity, the topic of this paper.

A fairly large number of traffic conflicts analysis methods exist in the literature, however the vast majority have been designed for vehicle-vehicle interactions. While some of them have been applied to modelling conflicts between vehicles and pedestrians, none of them has been developed for shared space. The aim of this paper is to present a new vehicle-pedestrian traffic conflicts technique with the prospect of applying it to the assessment of both conventional and shared space environments.

The work described has been conducted as part of a traffic monitoring programme of the Exhibition Road project, comprising the conversion of the layout of the Exhibition Road site in London's South Kensington area from a dual carriageway to a single, shared surface. The present is the first of a two-part study (before- and after-implementation) and involves the application of the new method on the – currently – conventional layout, with the second part (application on the new shared space layout) planned to take place following completion of the scheme in 2011.

The paper is structured as follows: Section 2 sets out the background of the study through a review of traffic conflicts techniques and the assessment of their suitability to model vehicle-pedestrian conflicts. Section 3 describes the new vehicle-pedestrian conflicts analysis method developed. The implementation of the new method, including the description of the test site, the collection of the data required and the results obtained are outlined in Section 4. Section 5, finally, concludes the paper and gives recommendations for further research.

2 BACKGROUND

The background of the present study is reported here, including a literature review of traffic conflicts analysis methods, followed by an assessment of the suitability of existing techniques for vehicle-pedestrian conflicts and for shared space environments.

2.1 Literature review

Traffic conflicts analysis has been viewed as an effective way of preventing collisions from happening since its inception in the late 1960's (8), as it can provide valuable information on potentially dangerous road sites before collisions actually happen on them. A substantial amount of research has been conducted on the topic, leading to the development many traffic conflicts techniques (9-17). While initial analysis methods were purely qualitative and used only subjective statements to identify and characterise evasive actions of road users in response to conflicts, newer methods have become more quantitative and have provided definitions for measures of the severity of conflicts (9,14,16). Advances in imaging technology have also played an important role, as the observation of sites and the application of traffic conflicts techniques has become simpler (17).

Traffic conflicts analysis is now a well-known and widely-used tool around the world, and although some traffic engineers still feel sceptical of the concept, most Western countries have developed or used some form of traffic conflict analysis, as quoted in (13). Examples of techniques in use today include the "Swedish Traffic Conflicts Technique" (STCT) from Lund University in Sweden (10), the "US Department of Transportation Conflict Technique" (USDTCT) from the Federal Highway Administration in the US (12) and the "Institute of Highways and Transportation Conflicts Technique" (IHTCT) from the Transport and Road Research Laboratory in the UK (11). More specifically, the STCT focuses upon evaluating the time to collision and vehicle speed at the beginning of an evasive action using a graph, which has disaggregating lines to categorise the different conflicts according to severity. The USDTCT and the IHTCT, on the other hand, are based on categorising the various comprising elements of the conflict and creating levels of severity for each element, such that by summing up the given element levels an overall grading of the severity of the conflict can be obtained. Examples of traffic conflicts techniques can also be found outside of Europe and North America, such as in El Salvador and in the Philippines (18).

Conventionally traffic conflicts techniques have been used for vehicle-vehicle conflicts, as they were intended for the assessment of the safety of road intersections. However, some examples of work on conflicts between vehicles and other road users can be found in the literature, mostly for the purpose of assessing the safety of pedestrian crossings and the interactions within mixed traffic flows. Some researchers have implemented existing traffic conflicts methods for modelling vehicle-pedestrian interactions, and as such, both the STCT and the USDTCT have been used to analyse conflicts with pedestrians; in other studies, nevertheless, new techniques have been devised. Taking specific examples of the former case, the so-called "US method" for traffic conflicts is used in (19) to model the interaction between left-turning vehicles and pedestrians at signalised intersections and the STCT is applied in (20) to assess the efficiency of the safety regulations for vulnerable road users at intersections in Beijing. Regarding new techniques, an early pedestrian conflicts technique is described in (21), involving the qualitative categorisation of conflict types and severity, and quantitative methods are presented in (22) and (23), where speeds and decelerations are used to quantify pedestrian conflicts at Pelican crossings and left-turn situations respectively. The analysis process is also automated in the latter two studies, using pneumatic tubes in (22) and a video detection technique in (23).

2.2 Suitability for vehicle-pedestrian conflicts

Although a number of conflicts analysis methods have been used to model vehicle-pedestrian interactions, none of them has been developed with shared space in mind. The importance of this aspect results from the fact that, conversely to conventional road environments, where the areas in which pedestrians have priority over vehicles and vice-versa are clearly defined and demarcated (e.g. pedestrian crossings), in shared space there is ambiguity. This means that the prediction of the trajectories of vehicles and pedestrians in shared space is even more uncertain from the already uncertain situation in conventional environments, as the notions of carriageways, footpaths and crossings do not apply. This has an effect on the behaviour of both drivers and pedestrians, and naturally, it is expected to also affect traffic conflicts.

Taking existing traffic conflicts techniques and assessing them with respect to their suitability of modelling vehicle-pedestrian conflicts in both shared space and more conventional urban environments, the purpose-developed technique of (21) accounts for potential conflict categories between vehicles and pedestrians fairly comprehensively. However, it has the drawback of subjectivity, as it assumes that conflicts are only possible under certain conditions and it is mostly constrained to either formal pedestrian crossings or to illegal free crossings of pedestrians. The methods of (22) and (23), on the other hand, whilst being quantitative and more objective, require a significant amount of data to be collected, which is often not possible as it may require the use of special equipment.

Considering the most commonly used conventional vehicle-vehicle techniques (STCT, USDTCT and IHTCT), these are not intended for pedestrian-vehicle analyses and have only been used for that purpose under specific conditions (usually to model pedestrian to left-turner conflicts), which makes them unsuitable to model shared space conflicts. Specifically, the STCT (10) looks at 'time to collision' and 'speed' to mark conflicts as serious or not, and while being relatively simple and easy to use once the data has been collected, it does not seem to have any physical basis, other than vehicle-vehicle conflict data, to show the formation of time-speed curves, which form the backbone of the analysis. In addition, it requires detailed measurement of the input variables, which may necessitate the use of special equipment. The USDTCT (12), on the other hand, mainly revolves around the number of conflict occurrences rather than their severity, and is also based on American junctions, which makes it unsuitable for pedestrian-vehicle conflict analysis in other environments, including shared space. Finally, the IHTCT (11) considers four factors within the conflict, that is 'time to collision', 'severity of evasive action', 'complexity of evasive action' and 'distance to collision', and unlike the STCT, it does not involve graphs but aggregates each factor into levels of severity and comes up with a final grade of conflict severity, ranging from 1 to 4. Nevertheless, similarly to the other two techniques, the IHTCT is intended for vehicle-vehicle conflicts and is therefore unsuitable for vehicle-pedestrian interactions and for shared space environments.

It is therefore conjectured in this study, that no suitable vehicle-pedestrian conflicts analysis method for shared space actually exists in the literature, requiring a new technique to be developed. The adaptation and/or modification of an existing technique to account for vehicle-pedestrian conflicts can of course be a first step towards this, and among the techniques available, the IHTCT seems to be advantageous. This is because it is simple and easy to implement, thus having the advantages of qualitative techniques, while at the same time being detailed enough to limit the subjectivity, like quantitative techniques. In addition, it is based on detailed descriptions of severity levels, which allows it to be adapted to pedestrian-vehicle conflicts relatively simply. As such, the IHTCT is chosen as the initial building block, from which a vehicle-pedestrian conflicts technique is designed for use on both standard and shared surfaces.

3 METHODOLOGY

The new vehicle-pedestrian traffic conflicts analysis technique developed in this study is based on the IHTCT. First the required modifications are summarised, and then the new method is presented.

3.1 Modifications to the IHTCT

When analysing vehicle-pedestrian conflicts, whether in shared space or in conventional road environments, a number of differentiating factors from regular vehicle-vehicle conflicts should be considered. First of all, it should be taken into account that in vehicle-pedestrian interactions two road users are "working" together as opposed to vehicle-vehicle conflicts, which occur due to one detrimental action by one of the vehicles. Pedestrians are more responsive and flexible (changes in course and speed are easily performed), and are also subjected to less restrictions than vehicles on the road (speed limits, manoeuvre restrictions etc.), which means that they can more easily take evasive actions. Furthermore, pedestrians are small compared to vehicles and therefore the corresponding evasive actions taken by drivers to avoid pedestrians are less extreme, as swerving around a pedestrian involves a much smaller deviation from the vehicle's course than swerving around another vehicle. These factors can positively affect both the occurrence of conflicts and their severity.

Due to the differences between pedestrians and vehicles with respect to conflicts analysis, modifications are made in the IHTCT. A complete description of the original IHTCT technique can be found in (11) and is therefore omitted here. Instead, the focus is on the modifications made to each of the four factors entailed in the IHTCT, i.e. 'time to collision' (Factor A), 'severity of evasive action' (Factor B), 'complexity of evasive action' (Factor C) and 'distance to collision' (Factor D).

Regarding Factor A (time to collision) it has been deemed necessary to round down the levels of severity for actions concerning pedestrians. Therefore, small alterations to the description of the highest two levels are made to reduce the number of conflicts entering these levels. For Factor B (severity of evasive action) on the other hand, the descriptors in the original IHTCT seem to work relatively well in describing each severity level and allow to a great extent for crossover between pedestrians and vehicles. An addition that is made is a five-level hierarchy of pedestrian movement, whose purpose is to back the initial descriptors and to aid the decision-making for a certain factor class when a conflict is intermediary. This hierarchy contains the stages: 'walk/stop' – 'jog' – 'run' – 'sprint' – 'emergency action'.

Considering Factor C (complexity of evasive action), this is a fairly well-stated and easily categorised factor, with obvious definitions for each level; nevertheless, due particularly to the ease and lack of restrictions on pedestrians in changing course and speed, the definition of a 'complex' evasive action is changed to the conflict involving not only a mixture of a change in speed and course, but also a moderate severity in this change.

Finally, Factor D (distance to collision) is kept the same as in the original vehicle-vehicle IHTCT, due to the fact that despite the ability of pedestrians to react and change speed and course more rapidly than vehicles, distances between the conflicting road users remain very important and may possibly have an impact on the severity of the conflict. However, changes are made to Factor D for observations performed at formal pedestrian crossings, where interactions are characterised by low speeds, short distances, greater awareness, and of course unrestricted movement by pedestrians. As such, new values are assigned to the definitions of levels of Factor D in the case of formal crossings, which are approximately half the ones used in the original IHTCT.

3.2 The new vehicle-pedestrian traffic conflicts analysis method

Keeping the original IHTCT definition of a conflict being "an observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged" (11), the new vehicle-pedestrian method, containing the modifications accounted for in the previous sub-section, is developed. This includes two steps: the classification of the severity of the four factors (A–D) through the observation of a conflict situation; and the determination of a conflict severity grade with the use of charts containing combinations of severity ratings of the individual factors.

It should be noted that ratings of the severity of the individual constituent factors of conflicts refer to both vehicles and pedestrians (in contrast to existing techniques that only consider the evasive actions taken by one road user, namely the vehicle), and therefore it is likely that two grades of conflict will occur as vehicles and pedestrians take evasive actions of differing severity and complexity. When such a case arises the present method takes the worst of the two grades to mark the conflict.

Starting from the rating of the severity of the four constituent factors individually, this is conducted according to the following classification:

Factor A: Time to collision

- **Long [Class 1]**: The point when the evasive action for the vehicle or the pedestrian (deceleration or change of direction) begins is much earlier than the point of the potential collision, had the road users kept their initial speed and course. This case also applies to occasions when either road user has to accelerate. The associated evasive action is usually of low severity.
- **Moderate [Class 2]**: The evasive action begins fairly close to the potential collision, which usually results in more severe braking and a possible change of direction.
- **Short [Class 3]**: The time between the point when the evasive action begins and the potential collision is short; this is usually associated with hard breaking and a change of course.

Factor B: Severity of evasive action

Pedestrian severity hierarchy: 'walk/stop' – 'jog' – 'run' – 'sprint' – 'emergency action'

- **Light [Class 1]**: Light, controlled deceleration or acceleration. For pedestrians this corresponds to a change up/down by one level on the severity hierarchy.
- **Medium [Class 2]**: Moderate, but controlled deceleration or acceleration. For pedestrians this corresponds to a change up/down by two levels on the severity hierarchy
- **Heavy [Class 3]**: Sharp, less controlled deceleration or acceleration. For pedestrians this corresponds to a change up/down by three levels on the severity hierarchy. This is likely to be combined with a change of course, which occurs after the deceleration or acceleration.
- **Emergency [Class 4]**: Sudden, uncontrolled deceleration or acceleration. For pedestrians this corresponds to a change up/down by four levels on the severity hierarchy. This is likely combined with a fairly instant change of course.

Factor C: Complexity of evasive action

- **Simple [Class 1]**: The road user either decelerates/accelerates in order to avoid a collision (braking without change in course), or changes course in order to avoid a collision (change in course without deceleration or acceleration).
- **Complex [Class 3]**: The road user takes an action involving a distinct (>45°) change of course and decelerates or accelerates with at least medium severity in order to avoid a collision (combined change of course and braking)

Factor D: Distance to collision

- **Far [Class 1]**: Greater than two car lengths (~10m) between the conflicting road users, when they begin to take action to avoid the collision. For formal pedestrian crossings this should be taken as greater than one car length (~5m).
- **Medium [Class 2]**: Between one and two car lengths (~5–10m) between the conflicting road users, when they begin to take action to avoid the collision. For formal pedestrian crossings this should be taken as between 0.5 and 1 car length (~2.5–5m).
- **Short [Class 3]**: Less than one car length (~5m) between the conflicting road users, when they begin to take action to avoid the collision. For formal pedestrian crossings this should be taken as less than 0.5 car length (~2.5m).

Following the classification of the severity of each of the four factors A–D constituting a conflict, the grades assigned are collated so as to determine an overall grade for the conflict. Conflict severity grades range from 1 to 4, with Grade 1 conflicts being characterised as 'slight' and Grades 2, 3 and 4 corresponding to 'serious' conflicts, of course with increasing severity. Each combination of ratings for Factors A–D corresponds to a specific conflict grade, as these are presented in the grading chart of Table 1.

It should be noted that the relationship between vehicles and pedestrians is such that both road users in general attempt to avoid collisions, such that the occurrence of conflicts is undesirable for both. An important element in this instance is misjudgement; this means that vehicle drivers and pedestrians often perform actions to avoid what they think are potential collisions, and therefore, the observer is required to judge in each case whether the road user is avoiding what is an actual collision or simply being overcautious and making an evasive action when there is no need to do so. Only occurrences of the former case are conflicts and should be included in the analysis, since the latter case represents the basic idea of interaction, in which no conflicts are involved. Hence, it is advisable to determine whether a conflict occurs through Factors A and D and then only use B and C to grade its severity, once its occurrence has been established. Similarly, the severity and complexity of pedestrian evasive actions may be greater than what is deemed necessary (e.g. a pedestrian can switch from a 'walk' to a 'run' where a 'jog' would have sufficed with the aim of minimising the risk); in such cases the ratings for factors B and C should be based on the 'necessary' rather than the actual avoidance action.

Finally, the intention of the road users in a conflict-like situation should be considered before characterising a situation as a conflict and assigning it a grade, that is, whether a road user is forced to take an evasive action or whether he/she chooses to do so. For example, vehicles stopping intentionally to let pedestrians cross or vice-versa (frequent actions in shared space environments) are simple acts of politeness and cannot be classified as conflicts. The same applies to natural actions of both pedestrians and vehicles, such as accelerations/decelerations or changes in course which would occur irrespective of the presence of the other road user, and which should not be categorised as conflict situations by the observer.

4 IMPLEMENTATION

The vehicle-pedestrian traffic conflicts technique introduced is implemented on the Exhibition Road site in London's South Kensington area using video data. This section presents the implementation setup and procedure, including a description of the implementation site and data collection, followed by a summary of the results obtained.

4.1 Implementation setup

Exhibition Road is an 800 m long dual carriageway road located in South Kensington, a district of the Royal Borough of Kensington and Chelsea (RBKC) in London and is home to three of London's most popular museums: the Natural History Museum, the Science Museum and the Victoria and Albert (V&A) Museum. The surrounding area of South Kensington is well known as a cultural centre, including other venues such as the Royal Albert Hall as well as many academic institutions, including Imperial College London. As the current streetscape of Exhibition Road is crowded (a problem exacerbated by numerous pedestrian barriers) and dominated by high traffic flows and parked vehicles, the RBKC is undertaking an engineering scheme, the 'Exhibition Road Project', which includes its conversion and repaving to a shared space (Figure 1). The project is being implemented over four years from mid 2008 to completion in late 2011, ready for the 2012 Olympic Games.

Exhibition Road is a useful site of implementation of the new vehicle-pedestrian traffic conflicts technique since it offers the possibility of extracting valuable conclusions on the applicability of the method in both standard and shared space environments. The former consists of the present study (before implementation of the Exhibition Road Project), whereas the latter is part of an after-analysis and will be the objective of a future study taking place post-completion of the Exhibition Road Project.

To conduct the necessary observations for the conflict analysis, video footage of the site has been collected for a period of seven days between 24 and 31 August 2008. The data has been collected through six high-mast cameras installed at four locations, which are characterised by a high concentration of pedestrian-vehicle interactions. These are the following (Figure 2):

- <u>V&A Museum entrance (Location 1 – Cameras A and B)</u>: pedestrians wishing to cross

Exhibition Road at this location need to detour by more than 100 m to reach the closest formal pedestrian crossing, whether to the North or to the South. As a result, they choose to cross freely which potentially results in high conflict occurrence numbers.

- Cromwell Road (Location 2 – Cameras C and D): the facility provided to pedestrians wishing to cross Cromwell Road to continue walking on the western kerbside of Exhibition Road is a staggered pelican crossing, which requires a detour and often long waiting times for a green man signal. As a result, the vast majority of the pedestrians use a "shortcut" by-passing the staggered crossing and coming into conflict with right-turning southbound traffic from Exhibition Road.
- Thurloe Place (Location 3 – Camera E): despite the existing configuration not posing an immediately apparent threat to the pedestrians (there is adequate provision of legitimate crossing facilities), the main problem of this location is that pedestrians wishing to cross Thurloe Place to continue their walk on Exhibition Road are usually exposed to long waiting times. This causes them to cross on a red man signal, thus coming into conflict with speeding traffic.
- Thurloe Street (Location 4 – Camera F): pedestrians using this location are faced with two problems: the non-provision of adequate pedestrian crossing facilities, and the insufficient space for pedestrians on the southern kerbside of the road, such that overcrowding results in a large number of free crossings. Coupled with high vehicle speeds and poor visibility for both vehicles and pedestrians, this is a location where the most serious conflicts are expected to be occurring.

As analysing the complete duration of the video data would take up a significant amount of time and provided that peak and off-peak periods exist in traffic conflicts as a result of peak and off-peak traffic and pedestrian flows, seven hours of analysis for each camera have been selected, giving 42 hours of footage in total for the whole site. These are:

- Sunday 24 August 2008: **12:00 – 13:00** (midday, when a large number of tourists enter and exit the museums) and **17:00 – 18:00** (evening rush hour, when tourists leave the museums)
- Bank Holiday Monday 25 August 2008 (public holiday): **12:00 – 13:00** and **17:00 – 18:00** (again midday and evening rush hour)
- Tuesday 26 August 2008: **08:00 – 09:00** (morning rush hour, offering an insight of the local residents' and workers' use of the road), **12:00 – 13:00** (again a busy time for tourists) and **17:00 – 18:00** (evening rush hour, with a mix of tourists and workers leaving the area, and locals returning)

The video footage is analysed using the new vehicle-pedestrian conflicts analysis method and conflict occurrences and their severity are identified. To evaluate the outcome of the implementation the result of the conflicts analysis is compared with accident occurrence trends, as these are extracted from three-years' worth of 'STATS19' accident data (24). In addition, a secondary analysis is conducted using the STCT in order to compare the result of the new technique with an existing method designed for vehicle-vehicle conflicts. Finally, dangerous locations of the current layout of the site are identified as a result of the analysis, along with any other potentially contributing trends to conflicts, including times of day and pedestrian characteristics.

4.2 Results

Following observation of the Exhibition Road site, the conflict occurrences and grades encountered by each camera are given in Table 2a. Looking at the general picture, it can be seen that over two thirds of the conflicts identified are Grade 1 with the number of more severe conflicts progressively reducing, so that only three Grade 4 conflicts are recorded. This is what would generally be expected from such a conflict analysis, as the grades of conflicts are designed to attempt to fill the gap between simple interactions to collision occurrences. Provided that considerably more interactions than accidents exist, one would expect the frequencies of interactions, conflict grades 1–4 and collisions to correspond to levels going up a pyramid.

Considering the results at individual locations, the most conflicts are recorded by Camera F (Thurloe Street), which seems to be in line with the expectation, but also with the plan of the Exhibition Road Project involving the conversion of this location to an access-only road, thus reducing traffic levels. In addition, Camera F also encounters more serious conflicts (Grades 2, 3 and 4) than the other cameras; slightly fewer serious conflicts are observed by Camera E (Thurloe Place). Cameras A and B (V&A Museum entrance), on the other hand, record few conflicts (four serious ones in 14 hours of analysis), though these may be attributed to the lower number of pedestrian crossings at the corresponding locations, due to the non-provision of formal crossing facilities. As the layout at the time of the analysis has not yet been converted to shared space, it is normal that many pedestrians are reluctant to cross the road at random locations and prefer crossing using designated facilities. Conflict occurrences and severity recorded by Cameras C and D (Cromwell Road) are more numerous than A and B, but fewer than E and F.

Comparing the conflicts with accidents numbers at each of the camera locations (Table 2b), it can be seen that these match up for Cameras A to E, with higher numbers of accidents happening at locations with increasing slight and serious conflict occurrences. As such, Cromwell Road (Cameras C and D) and Thurloe Place (Camera E) entail more conflicts than the V&A Museum entrance (Camera A) and experience thus more collisions. In contrast to that, however, Thurloe Street (Camera F), has the highest number of both slight and serious conflicts but is also characterised by the lowest number of collision occurrences among all locations, namely zero. This confirms the conjecture expressed by many researchers, that although a conflict may cause an accident, the actual occurrence of accidents is not solely related to conflicts and various other factors, such as the road geometry, speeds, visibility and street furniture also have some effect.

In order to evaluate the accuracy of the new conflict analysis method the results are compared with those obtained from the implementation of the STCT for Cameras A to D (the quality of the video footage of Cameras E and F is bad and does not enable the accurate measurement of speed, which is required in the STCT). The latter are shown in Table 2c, where it can be seen that the numbers of serious conflicts measured by the two methods are fairly similar, with the biggest difference being the two serious conflicts identified by the STCT as opposed to the new method. Overall it is found that, based on the 7 hours of observation and the three years of accident data, the two methods result in similar conflicts to accidents relationships, with an accident occurring roughly every 15000 serious conflicts; this value falls within the range suggested by the original STCT study (10). It is thus suggested that the two methods perform similarly well and that any discrepancies arising could relate to the fact that the STCT has been primarily designed for vehicle-vehicle rather than vehicle-pedestrian conflicts.

Assessing the functionality of the new method, finally, this is found to be good, as a result of the comparison of its simplicity with the STCT. Certainly calculating and inputting the classification of factors is much simpler than measuring speeds and times to collision, despite the fact that this introduces more subjectivity; after all, it may be advantageous to involve a small amount of subjectivity as this enables a gauge of behaviour and unaccounted factors to be taken into account. It is testament to the simplicity of the new technique that results have been obtained from Cameras E and F, as opposed to the STCT, whose implementation has not been possible due to the poor quality of the footage.

5 CONCLUSIONS

In this paper a new vehicle-pedestrian conflict analysis technique has been presented. Based on an existing vehicle-vehicle conflicts technique, the IHTCT, the new method has been appropriately adapted so as to account specifically for vehicle-pedestrian interactions, with a view of being used not only in conventional roads, but also in shared space environments. Through the application at an appropriate site using video data the technique has been found to be usable, with its main advantage being its functionality and simplicity compared to existing methods.

This has been the first use of the new technique and as such gaining an accurate measure of its accuracy and functionality solely from the present analysis could be misleading. How well the technique works is almost impossible to assess without further use and research, such that it becomes possible to identify whether or not it shows great fluctuations which may point out weaknesses. The importance of further research and testing becomes more apparent when considering the fact that even for current well-established techniques, there are debates as to how well these evaluate the safety of roads. The fact that the new technique, however, has been adapted from an existing widely-used method, should correspond to a reasonable initial standard, from which improvements can be made.

From the work described in this study, there is no gauge of how the new technique will hold up when used to analyse shared space environments, and although it has been designed with the knowledge and understanding that it is intended for them, no actual data from a shared surface has been collected yet so as to evaluate interactions and conflicts. However, work in this direction continues and the application of the technique to the Exhibition Road site post-completion of the Exhibition Road Project is an essential future task of the monitoring programme, part of which has been the work described in this paper. Further tests could also be conducted on other sites so as to assess the ability of the technique to perform generic vehicle-pedestrian conflicts analysis.

Irrespective of any further work on shared space, it may be of value to further assess the technique using different media. In particular the ability to calculate speeds of vehicles could not just offer further insight into the technique itself, but could also enable a more accurate and detailed comparison with other existing methods, such as the STCT. This could be done by using detectors or simply road markings in the video data, similar to existing speed cameras in the UK. It would also be helpful to complement the analysis with on-site observations, as this would provide the observer with actual experience of the event and its surroundings, which could throw more light on the potential causes of conflicts. Finally, it would be useful to additionally investigate other aspects of vehicle-pedestrian conflicts, such as special treatment for near-misses, the relationship between conflicts and traffic volume and the status of monitoring and data availability on traffic conflicts in Europe and North America.

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TABLE 1 Traffic Conflict Grading Chart

Factor	Grade 1 conflict – slight												
A	1	1	1	1	1	1	2	2	2	2	2	3	3
B	1	1	2	2	1	1	1	1	1	2	2	2	2
C	1	3	1	3	1	3	1	3	1	1	3	1	3
D	1	1	1	1	2	2	1	1	2	1	1	1	1

Factor	Grade 2 conflict – serious																		
A	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3
B	1	1	2	2	3	3	1	1	2	2	3	3	1	1	1	1	2	3	3
C	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	1	3
D	3	3	2	2	1	1	3	2	2	2	1	1	2	2	3	3	2	1	1

Factor	Grade 3 conflict – serious																			
A	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
B	2	2	3	3	1	2	2	3	3	3	3	2	2	2	3	3	4	4	4	4
C	1	3	1	3	3	1	3	1	3	1	3	3	1	3	1	3	1	3	1	3
D	3	3	2	2	3	3	3	2	2	3	3	2	3	3	2	2	1	1	2	2

Factor	Grade 4 conflict – serious					
A	2	2	3	3	3	3
B	4	4	3	3	4	4
C	1	3	1	3	1	3
D	3	3	3	3	3	3

FIGURE 1 Impression of Exhibition Road post-implementation of the shared surface

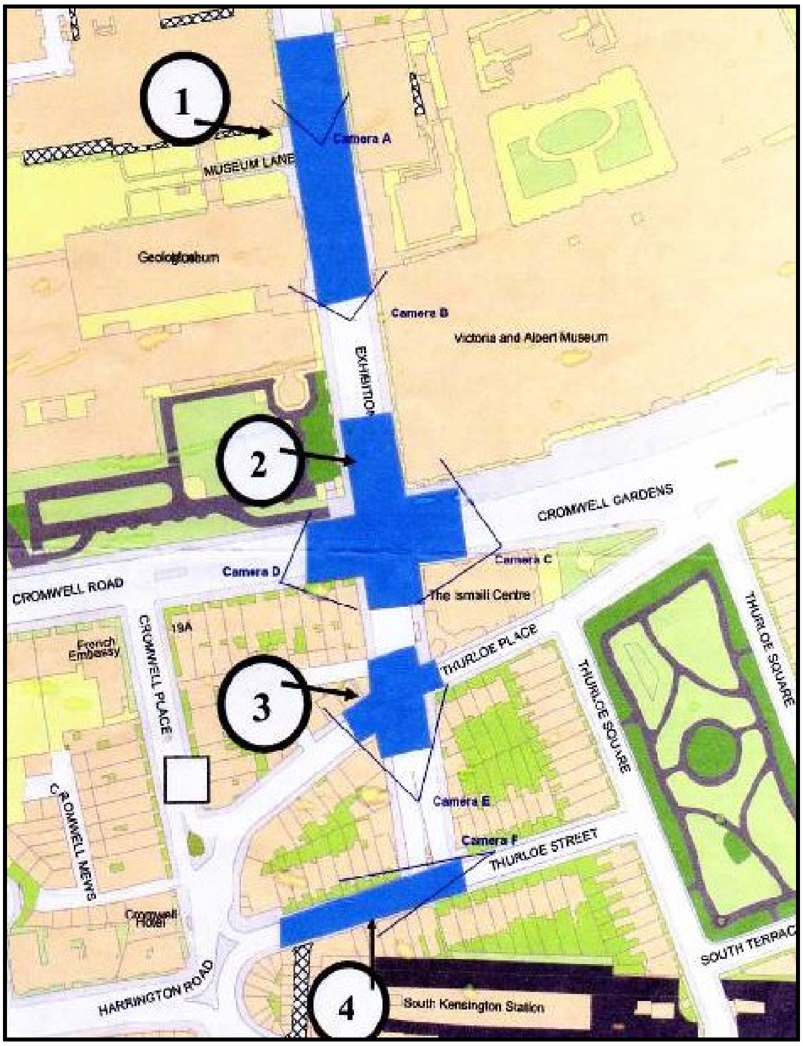

FIGURE 2 Camera locations at the Exhibition Road site

TABLE 2 Conflicts and their Severity (a), Conflicts against Accidents (b), and Conflicts from the STCT (c)

(a)	Camera						
	A	B	C	D	E	F	TOTAL
Grade 1	12	8	16	21	16	34	107
Grade 2	4	0	5	8	7	12	36
Grade 3	0	0	1	3	2	3	9
Grade 4	0	0	0	1	1	1	3

(b)	Camera					
	A	B	C	D	E	F
Slight conflicts	12	8	16	21	16	34
Serious conflicts	4	0	6	12	10	16
Accidents	1	0	1	3	3	0

(c)	Camera			
	A	B	C	D
Serious conflicts	4	0	6	12
STCT serious conflicts	3	2	5	11
Accidents	1	0	1	3