Methods for Assessing Traffic Safety in Developing Countries

by Sverker Almqvist and Christer Hydén

Sverker Almqvist was born in 1953. He is a civil engineer with a degree in Traffic and Social Planning from Lund University. He is a researcher in the Department of Traffic Planning and Engineering.

His professional work includes traffic safety research using the traffic conflicts technique, urban traffic, vehicle speed adaptation and communication among road users. Recent work concerns how new technology influences traffic safety. He is a member of the Swedish Association of Transportation Planners and ICTCT International Cooperation on Theories and Concepts in Traffic Safety.

Christer Hydén was born in 1942. He is a civil engineer and has worked in the Department of Traffic Planning and Engineering since 1969. He earned the degree Teknologie Doktor in 1987, and was appointed professor in 1993. His doctoral thesis dealt with the development of the traffic conflict technique to assess and analyze accident risks by direct observation of nearaccidents in traffic.

Since 1974 he has led an interdisciplinary research group that has studied traffic safety as an interaction of vehicles, physical environment and human behaviour.

Contents

Acknowledgment

We would like to thank everyone who made possible the intense and successful field study in Cochabamba, which was essential for this report.

First we thank Gonzalo Landaeta and Architect Freddy Aranibar who initiated the study, and the local authorities for their interest and support throughout the work. We thank especially Dr Mario Urquidi Urquidi (formerly Honorable Presidente Concejo Municipal), the Mayor Manfred Reyes, Lic. Gonzalo Terceros (Honorable Presidente Concejo Municipal) and Jorge Ponce Torres (Director de Relaciones Públicas).

Civil engineer José Daniel Bustos Quiroga of the National Road Service in La Paz provided invaluable help during the entire fieldwork, both as interpreter and local expert.

The collaboration with the Cochabamba Roads and Transport Department under Architect Javier Ferrufino and his colleagues Jorge Rodriguez and Eduardo Cossio was crucial for the outcome of our work. The field studies could not have been done so successfully without the Traffic Police Department, under the leadership of Abel Guardia, and the support of Luis Antezana Perez. We hope that our collaboration and the results of this study will support the work of Javier Ferrufino and his colleagues to improve road safety in Cochabamba in the future.

Last, but not least, we give a warm thanks to Lic. Giancarla de Quiroga (Oficial Relaciones Internacionales) whose enthusiastic welcome, helpfulness and hospitality make all guests feel at home in Cochabamba.

Lund, October, 1994

Sverker Almqvist

Christer Hydén

1 Introduction

Problem

Traffic safety constitutes a major health problem in developing countries. About 350,000 people are killed on the roads of developing countries out of an estimated worldwide total of 500,000 (World Bank 1990), even though developing countries have a very small proportion of the motor vehicles in the world. Road accidents are a major cause of death, particularly amongst 5 – 44 year olds (Jacobs and Bardsley 1977). The economic cost of road accidents in developing countries was about one percent of their Gross Domestic Product, the same proportion as in developed countries, despite the lower level of motorization (Fouracre and Jacobs 1976).

Transport systems and infrastructure have expanded rapidly in developing countries, while little has been achieved in preventing accidents or lessening their severity. Not only are accident rates high, there are not sufficient resources to save the injured and help those who are left with permanent handicaps.

The traffic safety situation in developing countries is most often alarming. The result is not only much suffering but also the loss of scarce resources. Increased investment in traffic safety will definitely pay off in many ways. The difficult question though is how to approach the problem to obtain actual improvements.

Traditionally there are many areas in which safety actions are taken. The most common ones are education (driver training, training at schools, retraining programme), information (mass media campaigns, roadside information), law practice (laws concerning drinking and driving, speed limits, give way rules), law enforcement (speed, drinking and driving, rules at traffic signals, stop signs), planning (organization of the road network, modal split measures), occupant and road user safety (restraint systems) and traffic engineering measures (design of roads, intersections). The time frame of these measures varies, as do the organizational and resource demands. Planning measures for instance are primarily long-term measures. They aim at long term adaptation, e.g. of the road network to minimize risks, or change the modal split to encourage the use of safe modes of transportation. Engineering measures are more short-term in nature; for example, they aim at optimizing the roadway design from a safety point of view.

Considering how little is known about the effectiveness of local safety measures, particularly the generality of results for different countries and “traffic cultures,” the main contribution of researchers from a country with a relatively high safety standard could be to provide tools to assess and evaluate such safety measures. The tools should be possible to apply locally and to be used by local practitioners and researchers. There is potential for further collaboration, both regarding the use of the tools and the conclusions drawn from assessment work. Collaboration between experts and local researchers and practitioners requires a common basis. We can present knowledge about safety measures and experiences from a developed country, so their effectiveness can be evaluated locally by both parties.

The Traffic Conflicts Technique (TCT)
The Traffic Conflicts Technique (TCT) is a method of observation, where near-accidents are recorded and used for predictions of accident risk and for studies of events leading to accident situations. The core of TCT is the identification and recording of serious conflicts by human observers. These events can be characterized by the fact that the closeness to a collision is very imminent. The analysis of conflicts has great similarities with the analysis of accidents. One main difference is that the events leading to conflicts are more comprehensively described, as they can be directly observed by the specially trained observers. Conflict studies are easy to perform. No sophisticated hardware is needed, only a pencil and a recording sheet.

Traffic conflicts are common where pedestrians must cross a busy street.

(Serious) conflicts represent the link between “ordinary behaviour” in traffic and the “critical behaviour” leading to accidents. It is very often the most feasible way of predicting accident risks at individual locations. In view of the limited scope of this study, it was decided to focus primarily on the usefulness of TCT. It was concluded that TCT should be an important tool for safety assessment, even in developing countries, by predicting risks, linking each risk to behaviours, and following up the effectiveness of solutions with new conflict studies.

Even though conflict studies are often useful by themselves, the importance of supporting activities should not be neglected. The recommendations (Chapter 3) therefore include the use of accident analysis and behavioural studies as common and important back up activities.

The aim of this study was:

- To test the use of the Traffic Conflicts Technique by local researchers and practitioners in a developing country, which could lead to production of a complete safety assessment and evaluation procedure, best suited for local conditions.
- To test the usefulness of TCT in assessing safety at individual locations, to identify potential low cost engineering measures.
- To present a general review of known low-cost engineering measures likely to improve traffic safety in developing countries.
- To propose, as a case study, specific physical modifications to improve traffic safety at individual inter-sections in Cochabamba.

In this report we will focus on short-term measures that have a high potential for improving safety standards. The tools introduced in this report are primarily aimed at identifying problems at a micro-level for immediate action.

The aim of this study did not go further. If the proposed safety measures are implemented, follow-up studies would verify the findings.

Method

The city of Cochabamba in Bolivia was selected for the study, because its serious traffic problems were known. The city has a relatively high vehicle density, and traffic has increased rapidly in recent years. Local authorities were aware of the problem and were searching for solutions. A field study was carried out in April 1993 with the following main components:

1 Eight persons (three from the technical office of the city, four from the traffic police and one from the national road administration) were trained as conflict observers.

2 Conflict studies were carried out at three intersections. By switching intersections between the observers, comparisons could be done to test observer reliability and the relevance of the training technique that was used.

3 The results of the conflict studies were analyzed in Cochabamba in collaboration with local authorities, and conclusions were drawn regarding safety problems. Low-cost engineering measures were proposed.

A draft report was sent to all the Bolivian participants, and this final report was prepared in Lund after their comments.

Organization of the report

The report has two sections, which can be read separately.

Part 1 includes Chapters 1–3 and gives a short description of the background to the project, the considerations and the recommendations.

Part 2 consists of Chapters 4–5 and gives a fuller description of the Traffic Conflicts Technique and other observational tools. The field study in Cochabamba including safety measures proposed for intersections is also presented.

2 General Considerations

Traffic Safety is Complex

The vast majority of traffic accidents are the result of mistakes by any of the road users involved, but more important are the reasons that lie behind these mistakes. It is very clear that road design and planning play important roles, either directly by giving the road users incorrect information, or indirectly by producing a situation where the road users misinterpret the situation consciously or unconsciously. There are many examples of design measures that dramatically reduce the number of mistakes that lead to risks and accidents, by reducing opportunities for road users to make errors; and if errors do occur, making the environment more forgiving.

The importance of engineering measures does not seem to be fully appreciated yet. Hills and Baguley (1992) conclude:

> In developing countries, it would seem that past attitudes still predominate, with planners and engineers still almost exclusively preoccupied with the problems of construction and maintenance. All too frequently, roads and road systems are being built or upgraded with little consideration being given to road safety; as a result blackspots are still being created.

There is, however, a major problem. It is difficult to predict how road users will react to any change of the physical environment. There are many examples of how the so called "engineering effect" of a measure, i.e. the expected safety effect if road users would change their behaviour in the right way, differs considerably from the "actual effect" (Evans 1985). The actual safety effect is very often dramatically lower, and sometimes even results in an increase of accidents. A phrase that summarizes the underlying phenomenon is "behavioural adaptation." It means that road users adapt their behaviour to their perception of the new situation. The most common adaptation is when road users feel that safety is improved, which leads to a tendency to behave more "nonchalantly," and leads to higher speeds. A recent Finnish study offers an excellent demonstration of the problem: The introduction of reflector poles along rural roads is primarily done to improve visual guidance for drivers in the dark, thereby helping them avoid driving off the road. This is obviously also perceived this way by drivers; the results showed that driving speed in darkness increased, and at the same time injury accidents in darkness increased by as much as 60%.

The conclusion is that the success of a safety measure depends not only on its primary effect, i.e. how it influences the target behaviour, but also how different side-effects may influence the outcome. It is very obvious that behavioural adaptation is the most important element in this context.

A successful safety strategy must therefore be based on a comprehensive, and qualitative, knowledge about the whole process that results in some kind of safety outcome. It is for instance necessary to obtain a clear picture of what precedes accidents, in terms of behaviours, and what lies behind the fact that certain events, or combinations of behaviours, lead to critical outcomes from a safety point of view, and that other combinations do not.

Integrated Strategies are Needed

The complexity of the safety problem makes it clear that a successful safety programme is not one-dimensional. Actions in all the areas of education, information, legal measures, enforcement, and engineering and planning measures must support each other. The overall goal is greater traffic awareness through better understanding, competence, willingness, care for other road users and skill in traffic.

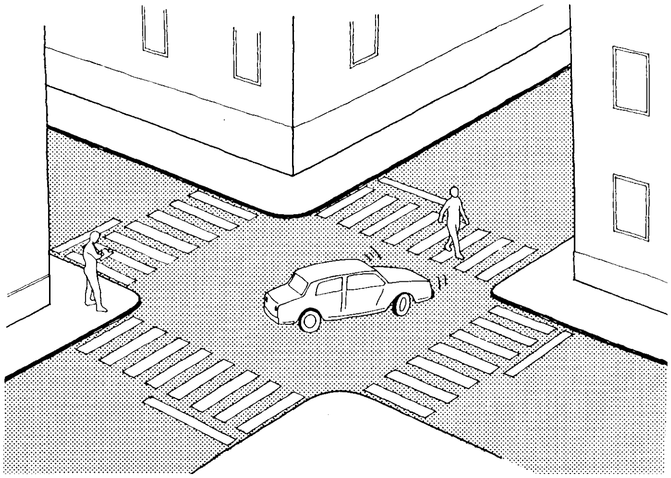
One main ingredient in a successful traffic safety programme is organization. There is a great need for a strong central coordinating body. There is also a great need for experts to collect, analyse and synthesise all the necessary information, to reach a sufficiently high standard of knowledge that safety issues can be "accepted," understood and permeate all areas requiring action.

One important task for a coordinating body is to build up "local knowledge." Knowledge about safety problems and their treatment can only partly be generalized. Local aspects at national level (the general frame under which traffic is performed), regional level (special conditions, practices, etc.), and local level (design elements, etc.) give different prerequisites. Experiences might differ between locations, regions or countries. A local strategy must therefore be largely based on knowledge obtained locally, which requires comprehensive tools to assess the safety situation.

Evaluation Tools

Accident analysis has been a major tool in safety assessment, since accidents are the ultimate result of a poor safety situation. Accident analysis is however not too useful for the assessment and evaluation of locally applied measures. Accident numbers are too small; reporting is biased; and descriptions of the events leading to accidents are not very informative. One might say that accident analysis is a "desk tool," often conducted indoors without any link to "what is going on in the streets."

The weakness of accident analysis could lead to the conclusion that behavioural analysis should be used. Behavioural studies represent one extreme, where accident analysis represents the other. The problem is that behaviour in itself does not give any indication of the risk potential. Walking against red is a good example. It is generally much more hazardous than walking against green. At the same time studies have shown that jaywalking can be very different in nature (deliberate, non-deliberate, etc.) and the associated risks also very different (Linderholm 1984). Thus, to understand the nature of the problem, so that feasible countermeasures can be introduced,



The traffic conflicts technique is based on observation and documentation of well defined conflicts.

more precise information about the relation between risks and behaviours must be established.

TCT produces a link between behaviours and accidents. It has "one leg" on the behavioural side, through the continuous monitoring of behaviours and specification of behaviours that lead to a serious conflict. The "other leg" is on the accident side, through identification of near-accident situations (= serious conflicts) that have proven to have a close relationship with accidents (Hydén 1987).

Conflict studies make it possible to study locations, situations, special road user groups, etc., in such a detailed way that one can draw operational conclusions on what lies behind the problems detected and what can be done to avoid these problems in the future. Problems can be of general nature (road users behave generally in an unsafe way), or they can be of more specific nature (linked for example to the design of an intersection or of a road section).

Because of the linking role of conflicts, TCT can play a central role in a safety assessment. It must, however, be supported by accident analysis and behavioural studies. Accident analysis identifies locations, types of locations, types of road users, etc. that produce high accident numbers. Conflict studies is then used to identify the kind of problems that lie behind the accidents and the kind of measures that might be effective. Behavioural studies support conflict studies with more comprehensive and detailed studies to explain the presence of certain behaviours leading to accidents, or why this behaviour is more common than other behaviours that do not result in accidents.

With this comprehensive knowledge of what behaviour produces risks and the underlying reasons for this behaviour, one can hypothesise about remedial measures in any of the traditional areas, e.g. road design, campaigns, information, education, etc., thus addressing both general problems and local problems. Conflict studies can also be used in an "after" situation to test the hypotheses that were formulated, accelerating both the learning process and actual increase of useful knowledge.

Conflict Studies in Cochabamba

The City of Cochabamba

Cochabamba is the third biggest city in Bolivia with about 500,000 inhabitants. It is located 2,600 meters above sea level. There is a relatively large number of vehicles (officially 1 car per 6 inhabitants). A very dominant element on the streets is the large proportion of public transport vehicles, "collectivos." Walking is an important means of transportation, as in most developing countries. Biking, however, does not play an important role anymore, probably because of the high risks perceived by potential bikers.

From a traffic safety point of view, the situation in Cochabamba seems to be representative for many cities in developing countries. If one compares traffic deaths in Cochabamba with those in Gothenburg, Sweden, about the same size as Cochabamba, one finds that there are more than seven times as many road users killed in Cochabamba, and more than 13 times as many pedestrians killed. (Table 1). The high risks associated with walking are quite typical for cities in developing countries.

Table 1 Accidents in Cochabamba, Bolivia and Gothenburg, Sweden

	Total	Fatally injured	Injured
Gothenburg (1991):			
All accidents	1,100	15	1,085
Pedestrian accidents		5	145
Cochabamba (1992):*			
All accidents	2,253	115	604
Pedestrian accidents		66	356

* Source: Registro de accident esdel transito.
Many accidents are unreported, even if they resulted in injuries.

The Applicability of TCT

- TCT seemed to be applicable for the problems addressed in Cochabamba. The types of conflicts that occurred, and their severity, were very similar to Sweden. The higher frequency of conflicts than in Sweden was reasonable considering the expected accident frequency. It was concluded that the technique could be used without any modifications.
- A general finding from training conflict observers is that learning does not stop at the end of one week's training. Further application of the technique improves gradually the detection and scoring of the conflicts. The eight observers in this study seemed to follow the "general learning curve" quite well. They all grasped the idea of observing in the week of training, and reached a adequate degree of reliability, and further improvement could be expected.
- The training procedure used in this study was the ordinary one week of training led by an expert. It worked well without any major changes. For the long term and large scale use of TCT in developing countries a low-cost version of the training must be developed.

The Usefulness of TCT for Assessing Safety

The studies indicated that the technique was useful in its present form to study local safety problems in Cochabamba. The types of conflicts, their severity and the type of safety problems they addressed were all familiar in principle from Sweden and other countries in Europe, even though the distributions were different. A number of countermeasures were identified for each of three locations. Their effectiveness had been demonstrated in several studies in Europe, but this does not automatically prove their appropriateness in Cochabamba. There may be differences in road users' reactions to the new designs, but the principles applied are very simple, and there is no reason to believe that the introduction of the measures will have negative consequences. It is primarily a matter of adjusting the detailed design.

The latter only highlights the absolute need for a follow-up of the effectiveness of the measures. It is not within the scope of this study, but it is hoped that measures will be implemented, and that follow-up studies will be carried out. The findings from such a follow-up would be helpful for further work.

It is of course difficult to draw any final conclusions about the general applicability of the results, but the study supports the usefulness of TCT in a country like Bolivia. There is no reason to believe that conditions will differ so much in any other country or city that TCT cannot be used.

3 Recommendations

TCT and Other Assessment Tools

Using TCT

The central role of TCT in safety assessment is the reason for giving highest priority to the development of strategies for using the conflict technique in developing countries. It should be observed that the usefulness of the technique is primarily limited to intersections (locations where enough conflicts are concentrated), but urban traffic problems are largely concentrated to intersections. Conflict studies also cover general behavioural problems that have implications outside intersections.

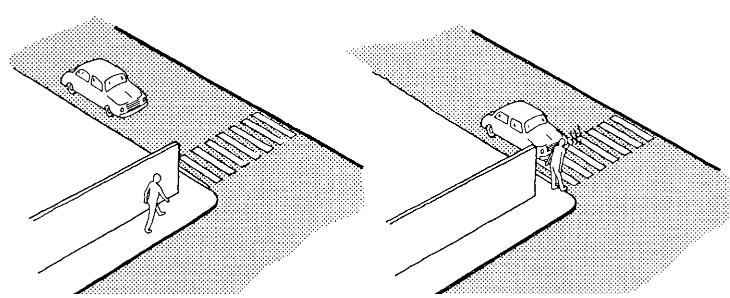
In this study the training of conflict observers was done by the authors in Cochabamba. For general use of the technique in developing countries a low-budget strategy must be developed.

> We therefore recommend the development of a training and application manual based on both written material and supporting information and examples on video. Such a manual should make it possible to train observers and to implement the technique in any country.

Along with material to train observers, the manual should contain parts dealing with the application of the technique: background (theory, areas of implementation of the technique, etc.), planning of studies, execution of studies, analysis of results, conclusions.

All training should be organized by one central organization in each country, e.g. the National Road Administration or central police, and they should take the responsibility for local adaptation of the manual, e.g. by translating it, adding examples based on local conditions regarding mix of traffic, type of road designs, etc.

In a transition period we would like to encourage potential users to try to apply the technique as described in the following section and Chapter 4. This should provide a start. Once the activities have begun, there are many options to continue the self-learning process.



To use the traffic conflicts technique it is important that the observer is trained in recognizing conflicts.

Using Assessment Tools

As was shown in Chapter 2 the combined use of different tools is usually necessary for successful assessment and evaluation.

We therefore recommend introducing a complete assessment procedure in developing countries consisting of the following four main steps:

Step 1: Identification of problems – priorities

Accident analysis should always be the basis for identifying safety problems, in terms of accidents and injuries, and to set priorities for action. The main kinds of problems that should be detected are "where" (locations, types of location, urban vs. non-urban, etc.), "when" and "what type" (accident type, type of road users involved, etc.).

The basis for priorities might be statistical clusters indicating a concentration of problems or risks, e.g. for a certain category of road user. The final selection of target areas or groups should be in terms of the goals set, i.e. to improve pedestrian safety in urban areas.

Step 2: Analysis of circumstances, reasons behind the safety problem, formulation of hypotheses

Conflict studies help identify the underlying reasons behind accidents. Behavioural studies can support conflict studies, since they can produce a more detailed and systematic analysis of certain behaviours, and thereby produce a better explanation for specific behaviours. The results of combining conflict studies and behavioural observation will give sufficient data about the problems to develop hypotheses about the kind of changes required.

Step 3: Identification of countermeasures

Based on the analysis of Step 2 it should be possible to identify relevant solutions, i.e. countermeasures that affect behaviours in the desired way. The analysis can be supported by general information about the safety effects of different countermeasures. There are some handbooks available, for example An Improved Traffic Environment (Danish Road Directorate 1993). Even though most of the experience reported comes from industrial countries, there is good reason to believe that the information can be useful to show how a certain countermeasure could influence behaviour in a developing country. Combined with the local information about behaviour, this should be sufficient to design proposals for testing.

From the studies in Cochabamba we have proposed testing a number of basic countermeasures of principle interest for all developing countries. These countermeasures, and principles, are presented in Chapter 5.

Step 4: Follow-up

As part of the effort to develop local knowledge and expertise to improve safety in local conditions, follow-up studies of implemented countermeasures are very important. This follow-up must be seen as an integral part of the whole assessment and evaluation procedure, and correctly handled accelerates leaning for the trainees.

The major tool for this purpose is conflict studies and accident analysis, most often in combination.

Types of Safety Measures

The studies in Cochabamba revealed clearly the behavioural issues behind the safety problems. The types of safety problems were very familiar, and led to recommendations to implement a number of low-cost design measures.

The main safety problems identified in the selected intersections in Cochabamba, and the relevant remedial actions that we proposed, are summarized below.

Speed problems

Vehicle speeds were often "too high" in that they contributed to a clear increase in accident risk, especially in interactions with pedestrians.

As speed influences not only the probability of an accident but also the severity of accidents, there is theoretically a high safety potential in lowering speeds. This is also verified empirically; even rather small reductions of mean speeds (5 – 10%) can produce quite high reductions of injury accidents (10 – 25%).

There are some low-cost design measures that have proven effective in reducing speed. The type of measure to use depends on the observed speed, the desired reduction in speed, and the kind of road.

This problem is universal, and the introduction of speed-reducing measures will most often increase safety.

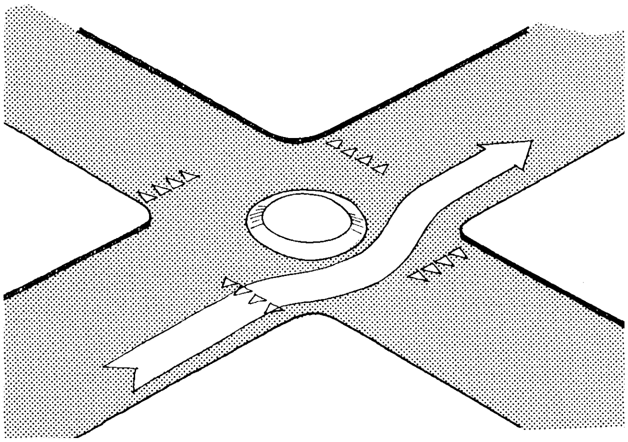
Street width and town planning

Street width is a very important factor, especially for pedestrians. The wider the street, the higher the risk. The streets in Cochabamba are often wider than warranted from the point of view of capacity. This is a fairly common problem in cities, so narrowing of streets is a general measure to enhance safety, especially for pedestrians.

General town-planning principles are also important for traffic safety. By making walking conditions attractive, pedestrians will use areas and paths that are designated for them, and adopt safe behaviours in a "natural way."

Inequity regarding responsibilities

Traffic at intersections in most cities in the world is organized in a similar way. The most common regulation is either traffic signals or giving way to traffic on the main roads. The latter creates safety problems. The give-way regulation psychologically gives drivers on the "main road" the idea that all responsibility lies with the intersecting traffic. Consequently speeds rise and the preparedness of road users on the "main road" to cope with interactive demands decreases. A change in this situation is highly warranted. In Sweden and elsewhere there are very positive indications of changing from an "ordinary give-way" to a roundabout, where all road users must yield. Swedish experiments showed that it was possible to rebuild, at a low cost, existing "ordinary give-way intersections" to roundabouts within the given space limits. Sometimes there was not enough space to build an ordinary roundabout where drivers must swerve around an island in the middle. Then an inner island, like an upside down plate with a slight elevation, was constructed. This island could be crossed by long vehicles making a left turn. In all other situations the roundabout functioned as an ordinary one.



A well designed roundabout has a high safety potential.

Speeds were reduced considerably, and injury accidents were approximately halved by this countermeasure. As the majority of accidents occur at intersections, the countermeasure could have a major influence on the accident rate. There is no reason to believe that developing countries would differ very much from industrial countries, both concerning the before situation or how drivers would react to the measure itself.

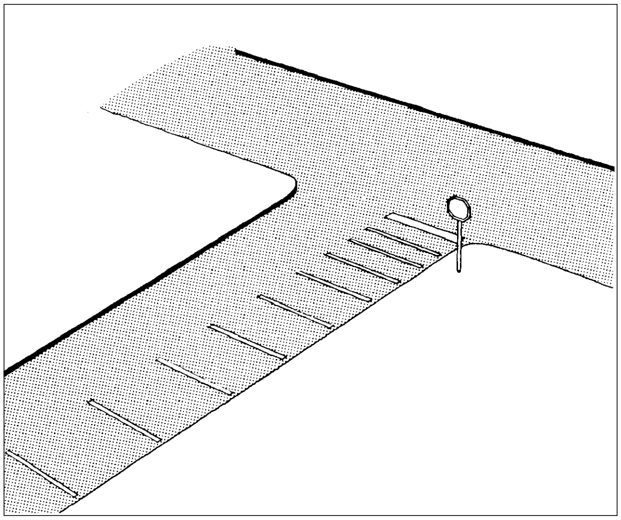
It must be stressed, however, that the local situation is of great importance in the design of a countermeasure. It is therefore recommended that wherever traffic safety improvements are implemented, they are treated as a test and carefully monitored to see that they are effective under local conditions.

Table 2 Different Types of Speed Reducers

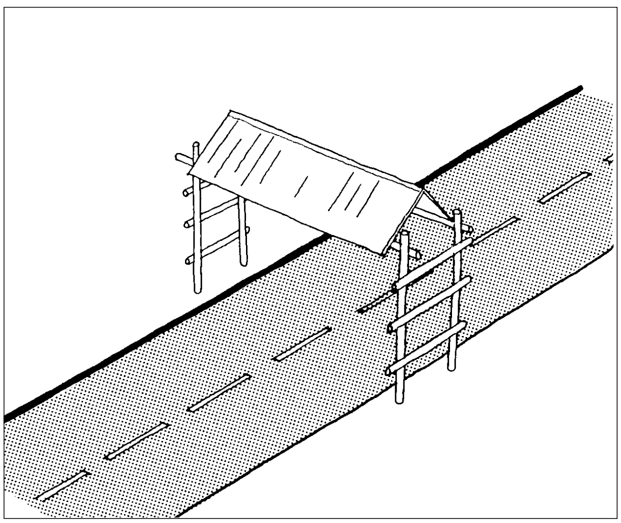
Main Type		Road Class		Desired Speed (km/h)			Annual Day Traffic (ADT)	
		Traffic Road	Local Road	60	50	40	> 3000	3000
1	Pre-warnings	•	•	•	•	•	•	•
2	Gates	•	•	•	•	•	•	•
3	2-lane raised areas	•	•		•	•	•	•
4	2-lane humps	•	•		•	•	•	•
5	Staggerings	•	•	•	•	•	•	•
6	2-lane narrowings from road centre	•	•		•	•	•	•

Source: Danish Road Directorate 1993.

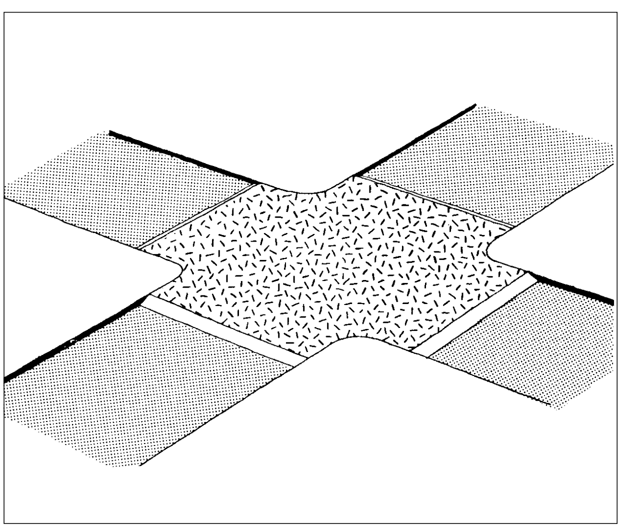
The following examples of road design can help reduce speeds and, consequently, the risk of accidents. The examples are based on solutions used in Europe. They should be seen as general principles that must be adapted to local traffic conditions. It is also important that each action is carefully adapted to the character of the neighbourhood and the surrounding traffic environment.



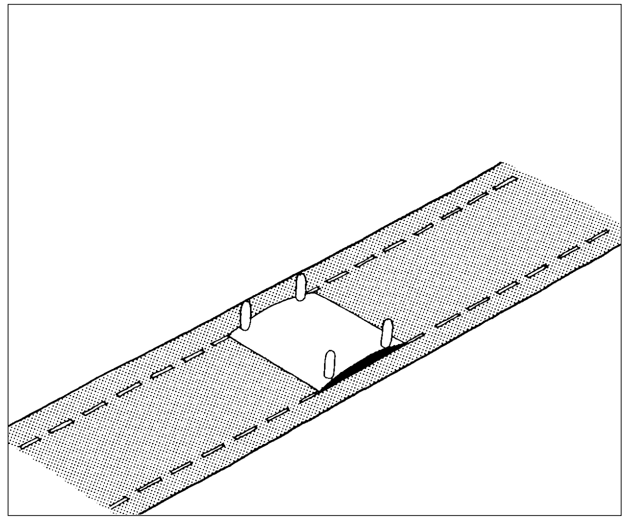
1 Pre-warnings can be a low-cost way to provide visual cues, to make the driver more aware of an intersection or hazardous area ahead.



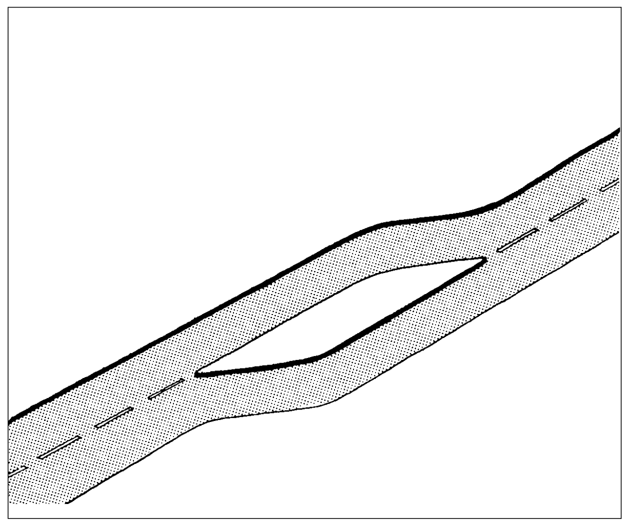
2 Gates can be designed in different ways, including light wood or metal structures, and are a signal to the driver to slow down.



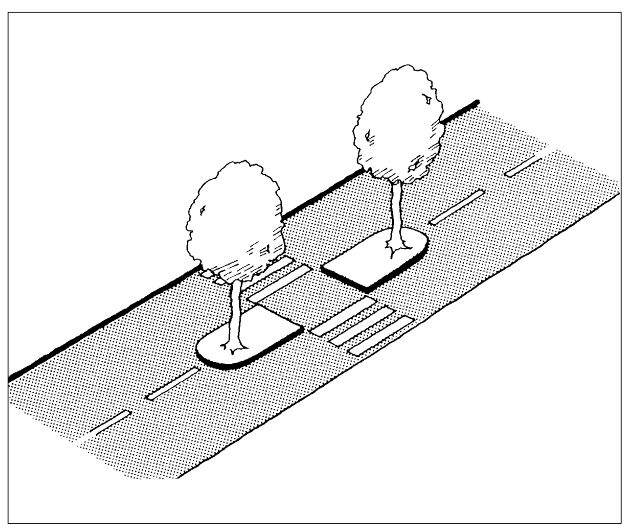
3 2-lane raised intersections are suitable in dense parts of the city where speed is already rather low.



4 2-lane humps are perhaps the most common way to force vehicles to slow down. It might be justified to make it easier for cyclists by putting bicycle paths along the sides.



5 Staggerings are most appropriate when building new roads.



6 2-lane narrowings from the road centre can be combined with pedestrian crossings to slow the car traffic and, at the same time, reduce the length of time pedestrians are on the road.

4 The Tools

TCT

One important basic hypothesis is that serious conflicts indicate a breakdown in the interaction between two road users, i.e. the perceived accident potential is so high that at least one of the road users would not like to be involved in the creation of a similar event deliberately (Hydén 1987).

The definition of the seriousness of a conflict is based on two variables: Time to Accident (TA) and Conflicting Speed (CS). TA is the time that remains from the moment one of the road users takes evasive action until a collision would have occurred if the speeds and directions of the involved road users had been unchanged. CS is the speed of the road user who takes evasive action, just before the evasive action. A serious conflict is defined by certain border values for TA and CS, as illustrated in the Box.

Observers are trained (normally one week) to identify serious conflicts on the ground. They record basic data about the conflict, such as date, time of the day, light conditions, weather, involved road users, TA, CS. The observer also makes a sketch describing the trajectories of the involved road users and if there are any other road users secondarily involved. Observers also record all circumstances that may contribute to the understanding of the process leading to the serious conflict. A conflict recording sheet is used (see page 19). For the interpretation of the result serious conflicts are converted to (police reported) injury accidents, through a matrix that takes into account the speed of vehicles involved and the type of road user.

For practical use in developing countries it is possible to introduce TCT even on a tentative basis. Observer training can be performed using the best tools available. Ideally observers are trained to estimate speeds by comparing their estimates with measurements by a speed radar; speed and Time to Accident estimates are practised by comparing scores from observations with video recordings of the same events. However, a tentative use of the technique is also possible, presupposing that a professional (a traffic engineer, a traffic policeman, etc.) leads the training, and makes sure that all observers are reasonably in agreement with each other.

The Box gives guidance in discriminating between serious conflicts and non-serious conflicts (only serious conflicts are included in the safety analysis), and assists in making a rough interpretation of the risk of an injury accident given a certain serious conflict. For operational purposes we have produced a rough matrix for converting serious conflicts to injury risk. Although the values in the matrix are based on Swedish experiences, the use of these conversion factors will produce much better predictions of injury risk when using the technique in other countries than not using any matrix at all.

The result of the procedure described above is a set of serious conflicts converted to relative injury accident risk. These conflicts, with all the information gathered for each of them, can then be used and analysed in the same way as accidents. Chapter 5 presents the application of the technique in Cochabamba in Bolivia as an example.

Definition of a Serious Conflict and Transformation to Injury Accidents

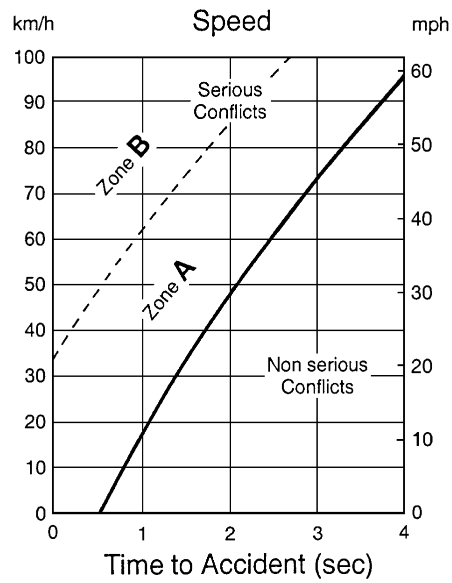
1. Conflict scorings:

- Conflict Speed (CS = (Estimated) speed when avoiding action starts)
- Time to Accident (TA = (Estimated) time that remains from the initiation of an avoiding action until the collision would have occurred).

2. Qualification of the conflict:

Recorded CS and TA-values are fitted into the diagram below:

N.B. Only serious conflicts are included in the further analysis!



3. Transformation into injury accidents:

The conversion factors from the table below can be used to get a rough relative estimate of the injury accident risk. Each serious conflict should be multiplied with the corresponding conversion factor. The sum of the converted conflicts is then computed to produce the total relative injury risk, per any category that is of interest.

Conflict type	Conflict severity[1] Low severity (zone A)	High severity (zone B)
Car [2] – Car “parallel” [3]	1	6
Car – Car “right-angle” [4]	4	20
Car – Unprotected road user	20	70

1 All figures per 100,000
2 Car stands for all motor vehicles.
3 Situations where the collision would occur at an angle of less than 90 degrees.
4 Situations where the collision would occur at an angle of 90 degrees or more.

Other Observational Tools

The most common supporting study is the measuring of vehicle speeds. Speed is the most important single behavioural measure that exists. It should be used to reveal non-compliance with speed limits or general speed regulations, and the results should be combined with the results of conflict studies to identify the most critical type of events from a speed point of view. Speeds can be measured by a radar gun or, if this is not available, by measuring the time it takes to pass over a measured stretch of road.

Other examples of behavioural studies are pedestrians' and vehicle drivers' compliance with traffic signals, use of zebra crossings, vehicle drivers' stop and give way behaviour. In all these cases the observations should be used to link serious conflicts with behaviour, to better understand why these behaviours occur. This demands additional observations. For instance, in the case of walking against a red light, one should try to explain the behaviour in terms such as "misunderstanding of the sequencing of the lights," "hurry," "available gaps." This additional information about circumstances can be very useful when one tries to understand the phenomenon and to identify relevant countermeasures.

This kind of behavioural observations can easily be performed with just pen and pencil. The important thing is to include them so that information is collected in a systematic and non-biased way, and that all the factors that might be of interest are included. This is entirely the responsibility of the individual planner. It is always advisable to perform at least a small pilot study to confirm that the assumptions of the study are correct.

5 The Field Study in Cochabamba

The City and its Traffic

The generally poor accident and injury situation in Cochabamba is described in Chapter 2.

From general observations and interviews with local authorities, some general observations about the traffic situation can be made:

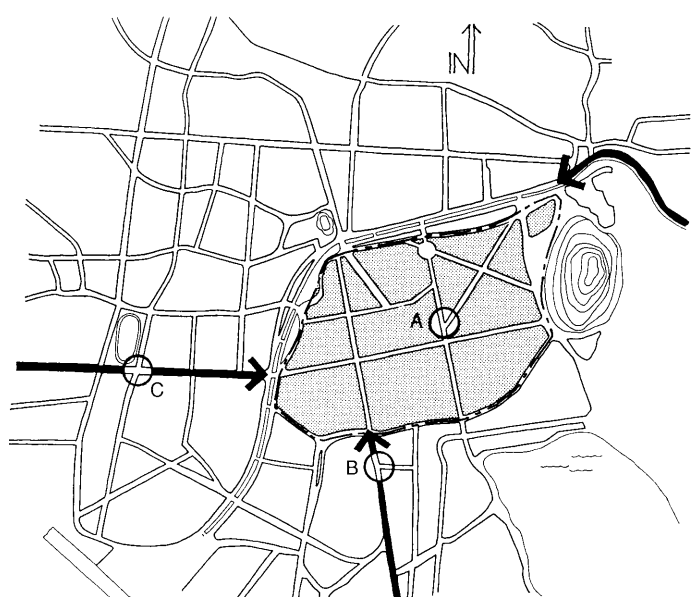
- Commerce is an important activity along the streets. Many people of different categories move around, cross the streets and affect the traffic in a hazardous manner.
- The number of vehicles is relatively large but it was difficult to get a reliable figure (official figures say there is one car per six inhabitants).
- The streets in the central part of the city are paved with asphalt, and in the outer areas the larger streets are paved with stone.

Traffic regulations and traffic rules are very rarely sign posted. In traffic signals the light cycles are very short, and it is difficult for pedestrians to get safely across the street during the time allowed. Generally one can say that there are many vulnerable road users, but there are very few facilities specifically for their benefit.

Driver training and education are generally poor. There is almost no training before taking a driver's licence, which has negative effects on traffic safety. Elementary knowledge of handling a vehicle is self-taught, which means that there is poor understanding of the importance of, e.g., speed and its effects.

Other examples of the inadequate experience of vehicle drivers are the random use of indicators and the very frequent use of the horn.

A dominant element in the streets is the large proportion of public transport vehicles "collectivos." Most



The City of Cochabamba. A, B and C are intersections used for studies. The central part is marked.

common are the Japanese eight passenger vans, often carrying 15–20 passengers. They drive along fixed routes but stop anywhere to pick up or drop off passengers. Many taxis circulate, sounding their horns for attention, looking for customers.

Scope of the Study

Eight observers were trained and tested. After the training, studies were carried out in three intersections, selected to represent three main problem areas. After half the observation time, the observers changed locations. The observations during the second half were carried out on the same week days as during the first half, thereby enabling a comparison of the scoring of different observers at the same locations "at the same time" (i.e. same week day and same time of the day). The scorings of the local observers were also compared with scorings made by Sverker Almqvist, who has 15 years of experience with conflict recording.

Based on the results, remedial measures were discussed with the local experts. We synthesized the discussions and made proposals for action. In this project we focused entirely on low-cost physical and regulatory measures that should be possible to implement.

The Training in Cochabamba

Initially time was spent for familiarization with the local traffic situation in Cochabamba, with the guidance of local staff from the Mayor's Technical Office. Information was also given by city planners about traffic conditions in the city. Statistics were provided by both the Mayor's Office and the Traffic Police Department. A set of potentially useful intersections for training observers and for conflict studies was visited and documented.

The staff to be trained in the TCT consisted of eight persons, three from the Mayor's Technical Office, four from the traffic police and one from the national road administration. The training period was five week days, normal for the course. Introduction and the theory behind the technique started the indoor sessions. Video recorded conflict situations were used for basic training in detection of those events. A very important part of the training is to understand and describe the causes leading to the conflict.

Estimation of vehicle speeds was carried out with a radar gun as a control instrument.

Normally the observers can estimate the speed with +/–5 km/h after half an hour of training. This speed estimating exercise starts every outdoor session or when there is a change of location. Estimating distances is practised in the same way, but also with the participant measuring strategic distances in the actual intersection, e.g. lane width, distance between the pedestrian crossings, traffic islands. After these steps the outdoor sessions continue with conflict observation. Simultaneous video recordings of the outdoor sessions give feedback to the observers through analysis of the recordings.

The training activities took place at three different intersections with some small variations in their design.

Intersections Studied

A Calle Colombia – Avenida Oquendo: Four-way intersection in the central part of the city, with one way traffic in both streets. (About 7500 vehicles/annual-average-day in each street.) Parts of the faculties of the School of Medicine are located on either side of the intersection, leading to many pedestrian and bicycle/moped movements. The general impression is a large intersection area. The geometry of the junction is slightly asymmetric which obstructs the sight from one of the entrances. Because of this the rules of right of way are not obvious to the drivers.

B Avenida Ayacucho – Calle Tarata: Av. Ayacucho is one of the most heavily used streets in the city centre (about 12,000 vehicles/aad). This three-legged intersection is located just opposite to the new bus terminal. Calle Tarata (about 3000 veh/aad) connects the bus terminal with the important market area. There are great differences between the two streets, such as function, width, etc.

C Avenida Blanco Galindo – Avenida Melchor Perez de Holguin: Avenida Blanco Galindo is the main road (about 20,000 veh/aad) between the two cities Cochabamba and Quillacollo. The intersection is located approximately 1.5 kilometre from the bridge into the city area. The road is completely straight for several kilometres with two lanes in each direction. The road standard allows high speeds. Besides the paved lanes there is also paths for pedestrians and bicyclists.

Many workshops and other activities are located along the road. The crossing road Av. Melchor Perez (approximately 3000 veh/aad) connects industrial zones with the main transportation roads, and carries a great number of heavy vehicles. In the future this street will become more important when the connection to the ring road is completed.

The conflict observers worked in teams of two. Each team spent two days in each intersection, in total 2 times 7.5 hours. The time periods for the observation included both the peak and off-peak hours: 7.30–9.00 (peak hour), 10.00–11.00, 11.30–12.30, 13.30–15.00 (peak hour), 15.00–16.30, 18.00–19.00 (peak hour).

Tests of Observer Reliability

During the training period a large number of situations (80–90) were scored and discussed in the analysis sessions comparing manually recorded and video recorded conflicts. The training focused on the detection of serious conflicts and estimating the speeds and distances for the road users involved, but also allowed the observers to explain the possible reasons for the occurrence of the conflicts. A reliability test was conducted on the last day of the training period, and all eight observers passed. The reliability rate, i.e. the percentage of serious conflicts that were scored correctly, compared with all serious conflicts that should be scored, plus all the non-serious conflicts that were scored, was calculated at 80%.

The results from the regular conflict studies can also be used to indicate the reliability of the observers. As two teams made observations at the same site, on different occasions but at the same time of the day and with roughly the same duration, the results of the two teams can be compared. Table 3 gives these results. There is great similarity in the results of the two teams. In only 3 out of 9 cases do the teams show significant differences in scoring. Considering that there may have been significant differences in traffic (one day is not exactly like another day), and that the observers were newly trained, these results indicate that the observers were well on their way in learning to use the conflicts technique in a reliable way.

Safety Measures for Intersections

Results of the Conflict Studies

The number of recorded serious conflicts in each intersection is presented in Table 3.

Table 3

Intersection	Car – Car	Car – Bicycle	Car – Pedestrian	Total
A	30 (15 ; 15)[1]	24 (11 ; 13)	12 (2 ; 10)	66 (28 ; 38)
B	20 (11 ; 9)	12 (2 ; 10)	16 (7 ; 9)	48 (20 ; 28)
C	25 (12 ; 13)	4 (2 ; 2)	4 (3 ; 1)	33 (17 ; 16)

1 Figures in brackets denote the scorings of the two observer teams.

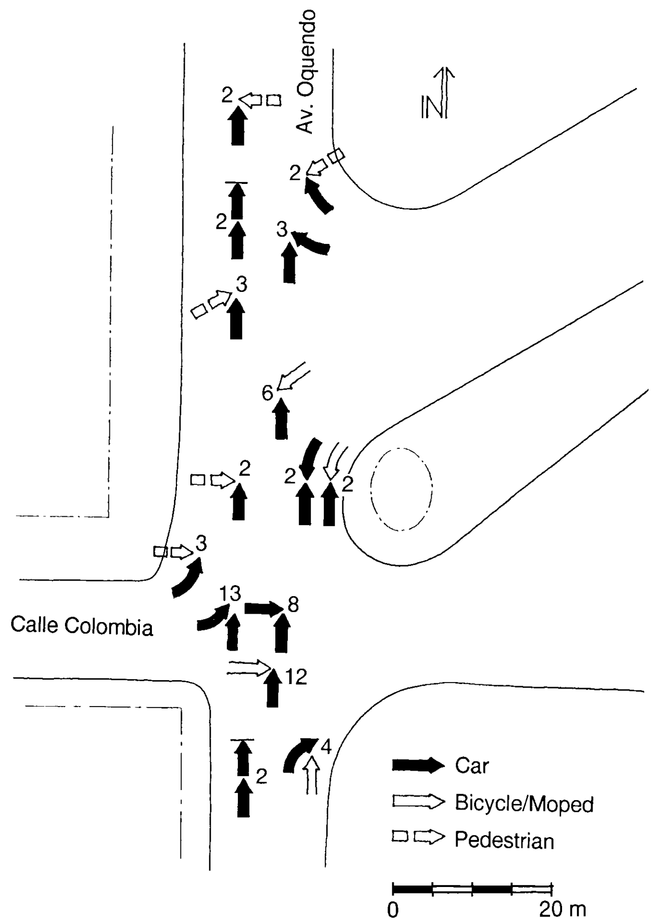
The number of serious conflicts recorded during the two day's study indicates several safety problems. First, the number of conflicts is comparatively high, with 3.3 conflicts per hour on average. In a large Swedish study the overall average was 0.6 conflicts per hour. The two intersections in the central part of the city Calle Colombia/ Avenida Oquendo and Avenida Ayacucho/Calle Tarata very clearly demonstrate the risks for pedestrians and bicyclists in the city centre generally, and at these two intersections in particular.

Example A

Identified Problems

- The asymmetric design of the intersection obstructs vision from the entrance of Calle Colombia;
- Unclear priority rules between the two crossing streets;
- Large number of pedestrians, bicyclists and mopeds cross unregulated;
- Large undefined areas in the intersection;
- High vehicle speeds from the Oquendo entrance.

A Calle Colombia – Avenida Oquendo



Graphic representation of the number of traffic conflicts observed.

Proposals

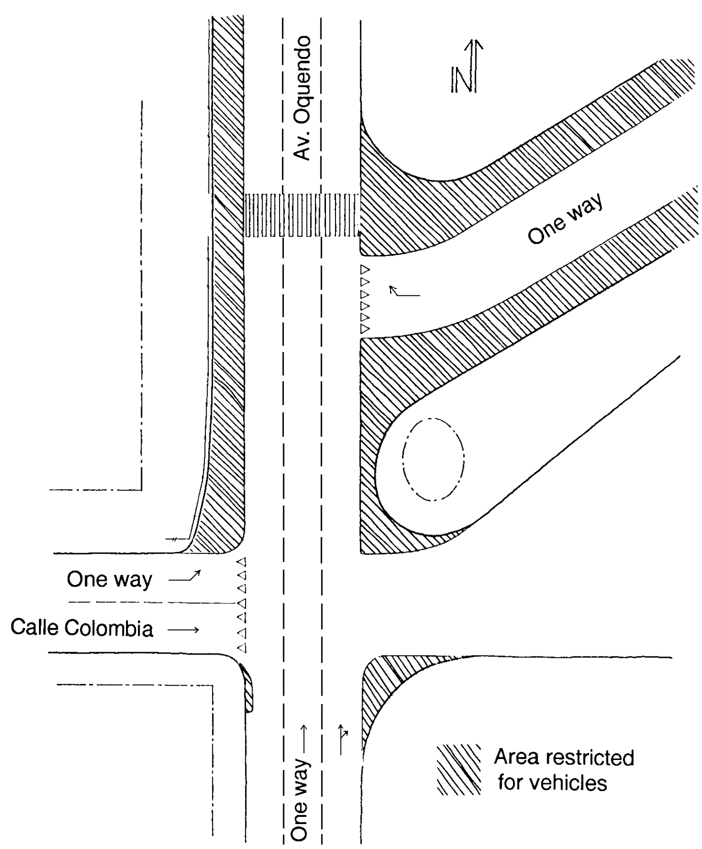
The study here indicated problems with large and undefined areas, unclear priority rules and unstructured pedestrian crossings. To improve safety in the intersection we will introduce

1 measures to reduce speed,

2 improved management of the road users' movements.

We suggest to using kerbstones and road surface markings to reduce the width of the two lanes in both directions. A further measure is to introduce a separate left turning lane from Calle Colombia. The street corners should be dimensioned with the radius as small as possible and with right angles. When this alteration is done, it is also easy to improve the symmetry and sight conditions.

Clear marked zebra crossings together with guardrails for directing the pedestrians to the pedestrian crossings.

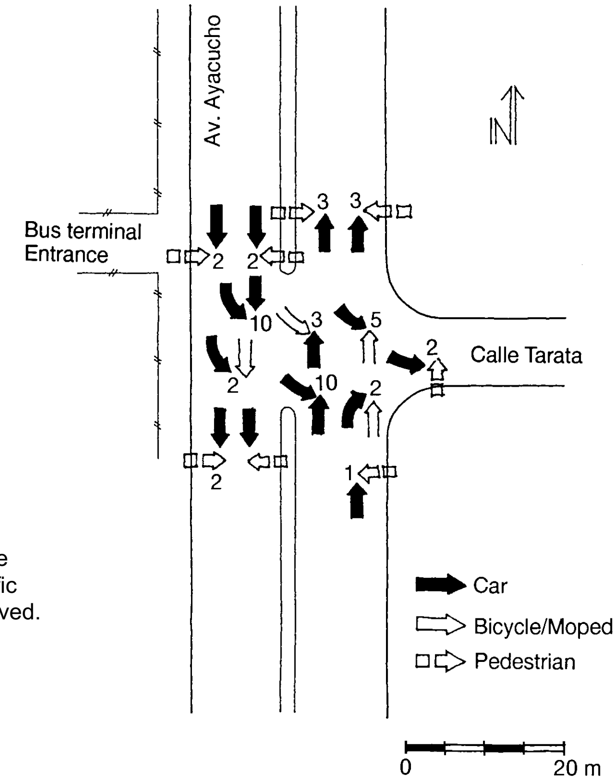


Example B

Identified Problems
The following safety problems were identified by the conflict study:

- Many pedestrians cross the wide Avenida Ayacucho with heavy and fast traffic between the main attractions, the bus terminal and the market area;
- Taxis and other vehicles stop unregulated outside the bus terminal entrance;
- High speed on the main street Avenida Ayacucho;
- Left turning cars from Avenida Ayacucho have difficulty in finding adequate time gaps for safe left turns;
- There are a large number of bicyclists at this point, as well as left turning cars.

B Avenida Ayacucho – Calle Tarata



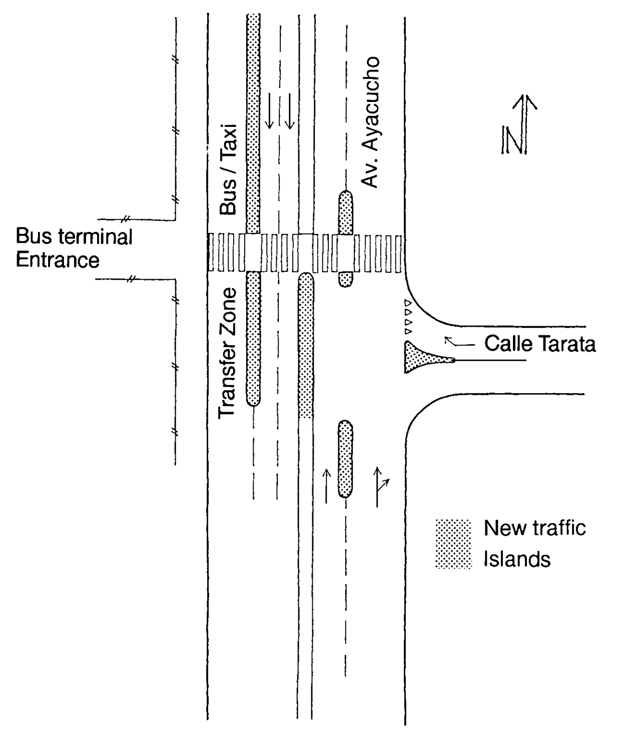
Graphic representation of the number of traffic conflicts observed.

Proposals
At this spot, just outside one of the pedestrian entrances to the bus-terminal, there are many people passing and crossing the busy street with fast traffic. It is essential to simplify crossing the street, which can be done by extending the central traffic island and adding a clearly marked crosswalk.

One important measure is to organize the taxi stop area so that passengers can start and finish their journey without standing in the street. This can be solved with extra traffic islands in the very wide south bound lane.

The other main measure to increase safety in this intersection is to stop cars from turning left from Avenida Ayacucho to Calle Tarata. This will increase the distance for those who stop outside the terminal and want to return in the direction they came from, since they have to continue to the next roundabout intersection some hundred meters further south.

It could be discussed whether the vehicle exit from the terminal should have traffic lights. This should make the main terminal entrance more attractive and increase traffic safety at the exit to Avenida Ayacucho.



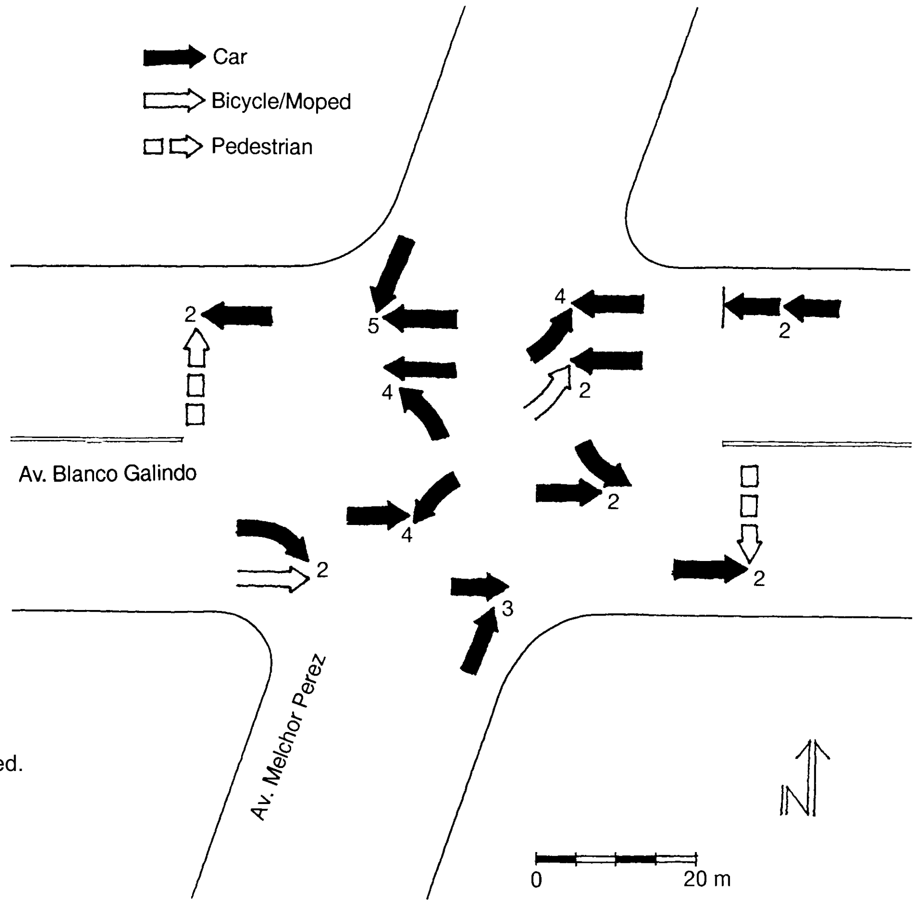
Example C

C Avenida Blanco Galindo – Avenida Melchor Perez de Holguin

Identified Problems

The following safety problems were identified by the conflict study:

- High vehicle speeds and variations in speed on Blanco Galindo;
- The width of the intersection can create difficulties for crossing road users;
- Cars turning to and from Blanco Galindo;
- The mix of road users on the street;
- The low section on the side road makes it difficult for heavy transport vehicles to enter Blanco Galindo.



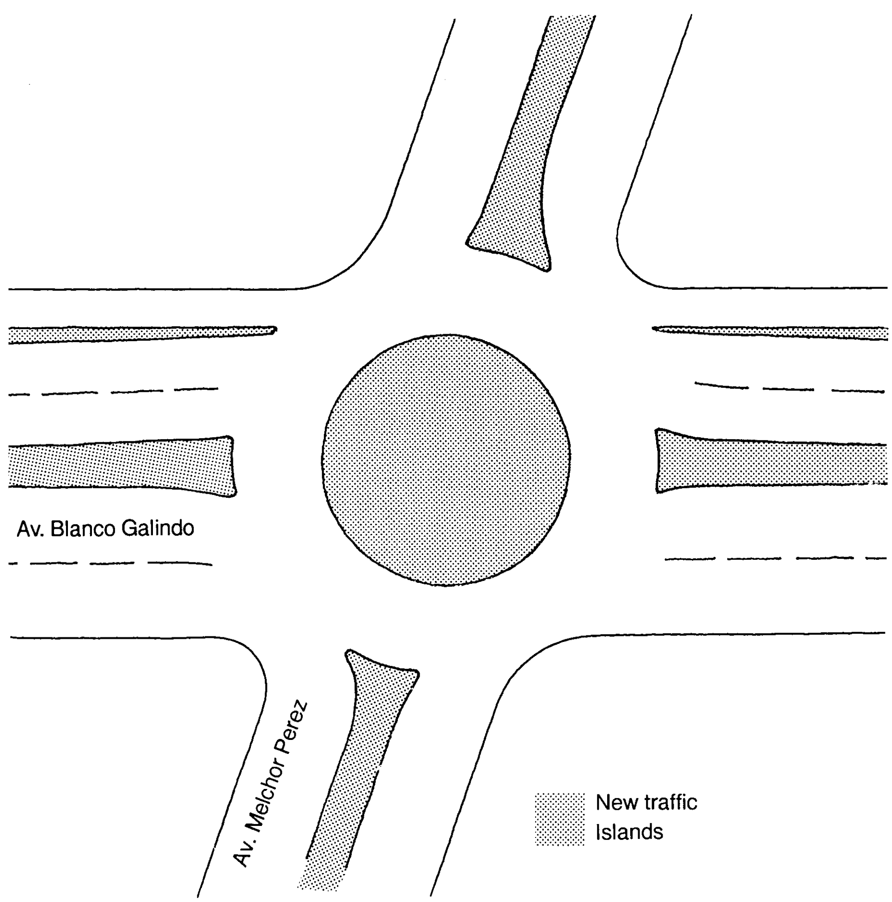
Graphic representation of the number of traffic conflicts observed.

Proposals

Conflicts between vehicles turning on and off the main road and the traffic continuing straight are the most frequent problem at this site. As the intersection is an important point for transportation of both goods and people, there is a problematic mix of road users.

We suggest therefore to introduce a roundabout with two marked lanes in each direction. The diameter of the inner circle should be designed so that speeds will be distinctly reduced. Attractive and safe facilities should be introduced for crossing pedestrians and bicyclists.

Supporting measures to be discussed are attractive bus and taxi stops, zebra crossings and perhaps a local lane for the different activities along the road.



Conflict Recording Sheet

Observer:______ Date:______ Number:______ Time:____

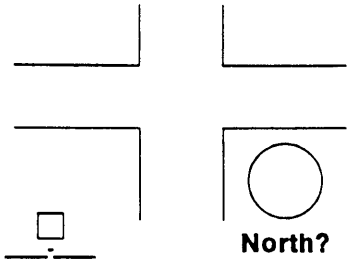
City: ______________________________

Intersection: ______________________________

Weather: Sunny ☐ Cloudy ☐ Rain ☐

Surface: Dry ☐ Wet ☐

Time interval ☐ - ☐ - ☐ - ☐ - ☐ - ☐ - ☐ -



	Road-user I	Road-user II	Secondary involved
Private car	☐	☐	☐
Bicycle	☐	☐	☐
Pedestrian	☐	☐	☐
Other	______	______	______
Sex (ped.)	M☐ F☐	M☐ F☐	M☐ F☐
Age (ped.)	____years	____years	____years
Speed	____kmph	____kmph	____kmph
Distance to coll. point	____mtrs	____mtrs	
TA value	____sec	____sec	
Avoiding action			
Braking	☐	☐	
Swerving	☐	☐	
Acceleration	☐	☐	
Possibility to swerve	yes ☐ no ☐	yes ☐ no ☐	

Other systematical information

	yes	no
speeding	☐	☐
visual hindrance	☐	☐
______	☐	☐
______	☐	☐

EXAMPLES

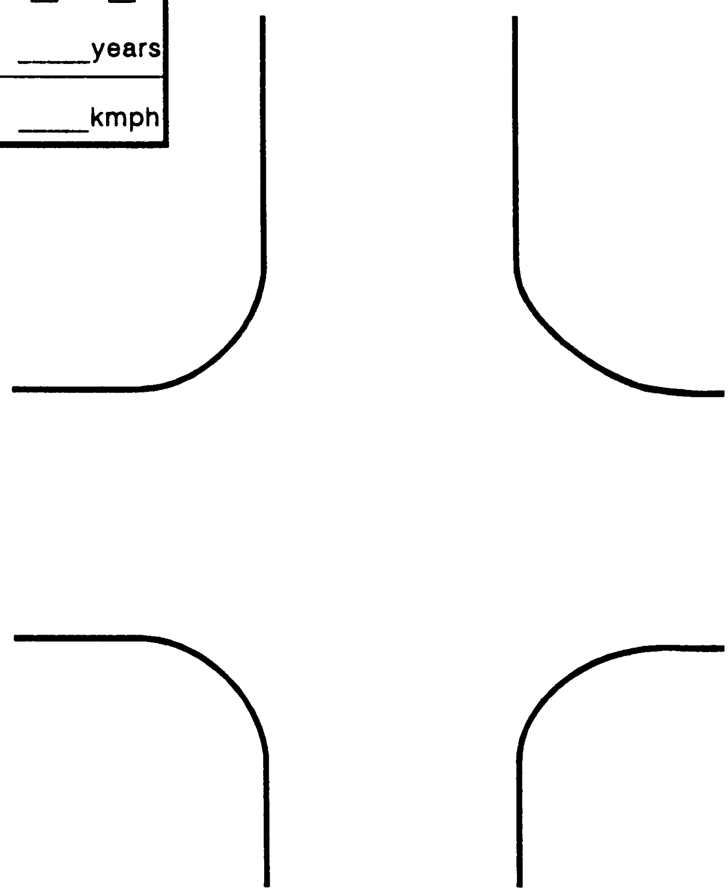
Description of the causes of event:

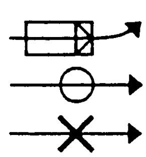
Continued on the other side ☐ ➡

Sketch including the position of the road-users involved

Please mark your own position with ⊗

If video is in use mark the camera position 





Private Car, Lorry, Bus..

Bicycle, Motorbicyle..

Pedestrian

References

____,
1993 An Improved Traffic Environment: A Catalogue of Ideas. Herlev, Denmark: Danish Road Directorate, Ministry of Transport.

Evans, L.
1985 "Human Behavior Feedback and Traffic Safety." Human Factors 1985:27:555–576.

1991 Traffic Safety and the Driver. New York: Van Nostrand Reinhold.

Fouracre, P.R. and G.D. Jacobs
1976 Comparative Accident Costs in Developing Countries. TRRL Supplementary Report 206. Crowthorne: Transport and Road Research Laboratory.

Hills, B.L. and C.J. Baguley
1992 "Engineering Approaches to Accident Reduction and Prevention." In Proceedings of the Seventh REAAA Conference, Singapore, 22–26 June 1992.

Hydén, C.
1987 The Development of a Method for Traffic Safety Evaluation: The Swedish Traffic Conflicts
Technique. Bulletin 70. Lund: Dept. of Traffic Planning and Engineering, Lund Institute of Technology, University of Lund.

Jacobs, G.D. and M.N. Bardsley
1977 Road Accidents as a Cause of Death in Developing Countries. TRRL Supplementary Report 277. Crowthorne: Transport and Road Research Laboratory.

Linderholm, L.
1984 Signalreglerade korsningars funktion och olycksrisk för oskyddade trafikanter (Signalized Intersection's Function and Accident Risk for Unprotected Road Users.) Lund: LTH Bulletin 55.

OECD
1990 Behavioural Adaptations to Changes in the Road Transport System. Report prepared by an OECD expert group.

Svensson, Å.
1992 Vidareutveckling och validering av den svenska konflikttekniken. Lund: Dept. of Traffic Planning and Engineering, Lund Institute of Technology, University of Lund.

____,
1992 The Swedish Traffic Conflict Technique / La Técnica Sueca de Conflicto de Tráfico. Lund: Dept. of Traffic Planning and Engineering, Lund Institute of Technology, University of Lund.

____,
1989 Trafikksikkerhetshåndbok. Oslo: Institute of Transport Economics, TÖI.

World Bank
1990 "Road Safety a Lethal Problem in the Third World." The Urban Edge 14(5), June 1990.