GRSP Beijing Project of Improving Vulnerable Road Users (VRU) Safety at Intersections

Ann Yuan, GRSP Country Manager for China
Yanyan Chen, Professor, Beijing University of Technology
Jifu Guo, Director, Beijing Transportation Research Center
Hu Meng, Beijing University of Technology
Shuling Wang, Engineer, Beijing Transportation Research Center

Abstract

According to the official statistics for Beijing during 2004-2005, over 50 percent of the crashes in the city occurred at the intersections, over 30 percent of crashes in the suburbs occurred at intersections and 43 percent of the crashes were related to VRU.

During 2006-2008, Global Road Safety Partnership (GRSP) carried out a 3-year project in Beijing to improve VRU safety at intersections. The key partners of the project include Beijing Transportation Research Center of Beijing Municipal Committee of Communications, Beijing University of Technology and Beijing Traffic Management Bureau (traffic police).

The project was divided into 2 phases: phase I - the situational study; phase II - to implement the chosen countermeasures (constructions) and to conduct the before/after data analysis for effectiveness evaluation. As a product of the project, a good practice manual is being developed by the local project team and it will be launched in 2009.

1. Background

Of all issues that people face daily, road traffic crashes are one of the most complex and most dangerous. Worldwide, nearly 1.2 million people are killed on the road each year and over 50 million people are injured with many of them become disabled for the rest of their life. It is recognized that a high economic burden has been caused by road traffic crashes - 65 billion US dollars is the estimated cost in low and middle income countries. However, road safety issues have not attracted enough attention from government and the media. The World Report on Road Traffic Injury Prevention[1] indicated that without appropriate action, road traffic fatalities are predicted to increase by 67 percent between 2000 and 2020, and in low-income and middle-income countries deaths are expected to increase by as much as 80 percent.

In the low and middle income countries including China, the majority of such deaths and injuries are among "vulnerable road users" (VRU) - pedestrians, cyclists and motorcyclists.

Without sufficient safety facilities on the road, urban junctions are the places where many crashes and traffic conflicts occur. However, the VRU's safety at the junctions has not been always considered sufficiently by people when planning cities or designing roads [2].

In the meantime, traffic efficiency is not satisfactory - congestion on the road is still serious.

Therefore, besides ensuring safety for all road users, particularly the safety of pedestrians and cyclists, it is important to maximize road traffic efficiency.

Taking into account this background, Beijing Transportation Research Center (BTRC), Beijing University of Technology (BJUT) and Global Road Safety Partnership (GRSP) worked together on a project to improve vulnerable road users' (VRU) safety at urban junctions in Beijing during 2006-2008. As a key output of the project, the team also prepared the good practice manual based on international and national good practice on VRU safety and experience gained from the project.

2. Objectives

- Focus on the high risk intersections in Beijing.
- Improve the VRU safety at the selected intersections by using low engineering cost countermeasures (channelization, barrier, pedestrian island, road signs, etc.).
- Provide a good practice guide for other cities in China.

3. Method

- Data collection and analysis

  Data collection consisted of two parts:

  a) collect and analyze the historical crash data

  b) collect and analyze the traffic and behavior data of the selected junctions on site.
- Data processing

  EXCEL was used to show the information collected and to identify the key information; SPSS was used to statistically analyze the crash data, and to identify the correlation among indices in the crash.
- Traffic Conflicts Technique (TCT) [3].

  In this project, Prof. Christer Hyden°Øs (Professor of Lund Institute of Technology in Sweden) Traffic Conflicts Technique (TCT) was applied for both conflicts identification and the before/after evaluation.

  For the process of conflicts identification at the junctions, the CDBASE software of Prof.

  Hyden was used (refer to the picture below). The system analyses the severity of conflicts after inputting the fixed indices.

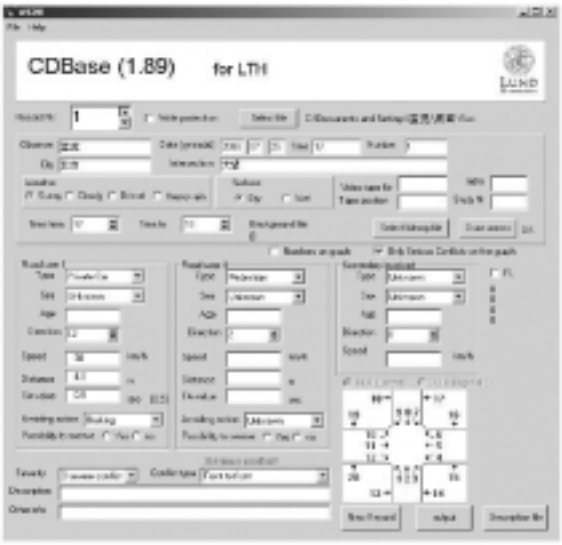


Figure 1. CDBASE software screen

- Using low cost engineering countermeasures (channelization, barrier, pedestrian island, road signs, etc.) for improvement.
- Using before/after data comparison to evaluate the effectiveness of the countermeasures used for the project.

Prof. Hyden's Traffic Conflicts Technique (TCT) was also used to evaluate the efficiency of the countermeasures. TCT is a non-crash-based safety estimation method that addresses the issues of measuring safety. It produces a link between behaviors and accidents. It has 'one leg' on the behavioral side, via the continuous monitoring of behaviors and specification of behaviors that lead to a serious conflict. The 'other leg' is on the accident side, thanks to the identification of near-accident situations (=serious conflicts) that have proven to have a close relationship with accidents. It is judged a serious conflict using the chart in Fig. 1 below. The observer takes two indicators from the junction video. The two indicators are conflicting speed (the speed when road user take action to avoid crash) and TA-value (the time from the road user taking action to the crash happening, if road user has not taken action), if the point in this chart is above the curve, the conflict is serious conflict [3].

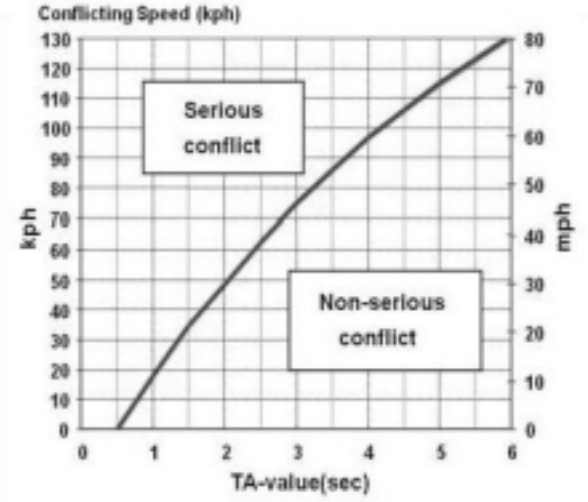


Figure 2. Conflict judging standard

4. Activities

4.1 Data Collection and Analysis of the Historical Crashes

In China, there are mainly two types of road crash treatments:
a) General treatments
b) Simple treatments.

General treatments are taken based on the conditions of the crashes causing death and serious injury, or crashes causing great property loss. Simple treatments are taken usually based on the conditions of self-reported minor injuries and little property loss.

From 2006 to 2007 the crash data from Beijing Traffic Management Bureau (BTMB) was as follows:

a) The general treatment crash data during December 2003 to December 2005
b) The simple treatment crash data during January 2001 to March 2006

The general treatment crash data was used to identify the black point, and find the crash prone areas from them. Thereby, the materials are provided for the next step of designing the targeted countermeasures to improve safety of vulnerable road user (VRU) at those high risk junctions and evaluate the effectiveness after the countermeasures taken. The simple treatment crash data for Beijing was used to analyze and evaluate the overall situation for VRUs safety on the road, and to understand the current VRU safety situation at junctions.

4.2 The on-site traffic data collection at the selected junctions

The collected data included:
a) The camera video records from Beijing Traffic Management Bureau (BTMB)
b) Traffic data from field investigation
c) Road user behaviors survey.

4.2.1 Data from BTMB include traffic volumes and speed at part of junctions

4.2.2 Traffic Data from Field Investigation

Based on the traffic data from BTMB, , additional data needs were determined to be collected from field observations. The field investigation consists of on-site videos recording conflict numbers and the characteristics of road users, (the video films can be played repeatedly afterwards in order to collect the necessary information), and on-site data collection on traffic volumes, vehicle speeds, queuing length, geometrical parameters of junctions and the existing safety facilities at junctions.

4.2.3 Road User Behavior Survey

In order to understand the effectiveness of the countermeasures taken, a before and after behavior survey was conducted via site observation and a questionnaire for different kinds of road users at the selected junctions. The behaviors included two stage crossing of the left turn bicycles, pedestrians using the existing safety facilities (zebra crossing, refuge islands, overpass and underpass), and the compliance rate with traffic laws and people's feelings of using those facilities. Depending on the situation, the sample size for each behavior varied from 50-200.

4.3 Site Selections

Based on the result of data analysis, and through the discussions between the local project team (BTRC, BJUT, GRSP) and Beijing Traffic Management Bureau (BTMB) six typical junctions were selected for improvement. The following factors were considered during the site selection:

a) The junctions that were high risk - the junctions had to be either the existing black spots or be with high numbers of serious traffic conflicts;
b) The location of the junctions - the location should not be too far away from the city
c) The type of the junctions - from a research aspect, different types of the junction were selected for the project.

The table below shows the general information of each selected junction.

Name	Numbers of Casualty Crash	Type of Junctions	Existing Safety Facility	Main Crash Type at Each Junction
Xidan	12	At-grade 4- leg interchange	underpass at north-south direction	Bicycle and pedestrian
Dongdan	3	At-grade 4-leg interchange	underpass at north-south direction; fly-over bridge at east-west direction	Bicycle and pedestrian
Dongsi Shi Tiao	11	Roundabout	Only the east has underpass	Bicycle
Jiang Zhai	6	At-grade 4-leg interchange	fly-over bridge at four directions	Bicycle
Chao Yang Park	2	At-grade T-intersection	underpass at west entrance	Bicycle and pedestrian
Da Wang	9	Under bridge	interchange bus stations and subway	pedestrian

Table 1. General information of each selected junction

Locations of the chosen junctions are shown at fig. 3 below:

Figure 3. The locations of each junction

4.4 Identifying the problems and countermeasures

4.4.1 Main problems at the selected junctions:

- Lack of channelization for left turn bicycles which causes many conflicts between left turn bicycles and motor vehicles at intersections.
- Some pedestrians do not follow the rules when crossing the intersection.
- Some of the non-motorized vehicles drive on the motor vehicle lanes.
- No traffic signals for pedestrians at the large intersections, and no safety island for pedestrians to wait for second stage crossing.
- The traffic conflicts of right turn vehicles with pedestrians and non-motorized vehicles.
- Poor design of bus stations.

4.4.2 The key countermeasures implemented at the selected junctions

- Setting up a left turn waiting line allowing the left turn bicycles to cross the street in two stages.
- Setting the signal to allow for right turn vehicles.
- Installing a leading sign and barrier to guide pedestrians using the existing facilities (such as: underpass or fly-over bridge).
- Installing refuge islands for pedestrian crossing.
- Modifying the length, location and radian of the barriers in the roundabout to separate the non-motorized vehicles from motor vehicles.
- Improving the bus station.

5. Results

5.1 Set up the waiting line for left turn bicycles for two-step crossing

Problems: Lack of channelization for left turn bicycles to across the junction, which caused many conflicts between left turn bicycles and motor vehicles.

Objectives: Increase the proportion of two- step crossing left turn bicycles, reduce the number of traffic conflicts and the risk of crashes, andreduce the speed of right turn vehicles.

Example: Xidan

Outcome: The pictures of before and after at Xidan are shown as below.

Before

After

By setting up the waiting line for left turn bicycles, the proportion of two-step left turn bicycles at the junction wa greatly increased. Almost 80 percent of left turn bicyclists are now using the waiting line to finish their crossing. The bar chart below shows the comparison of before and after data.

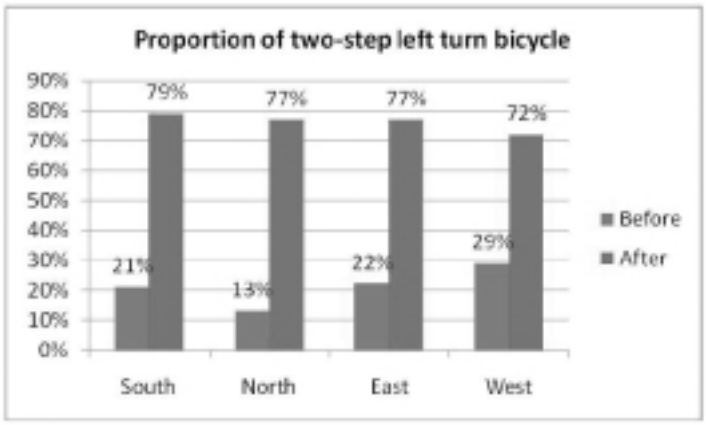
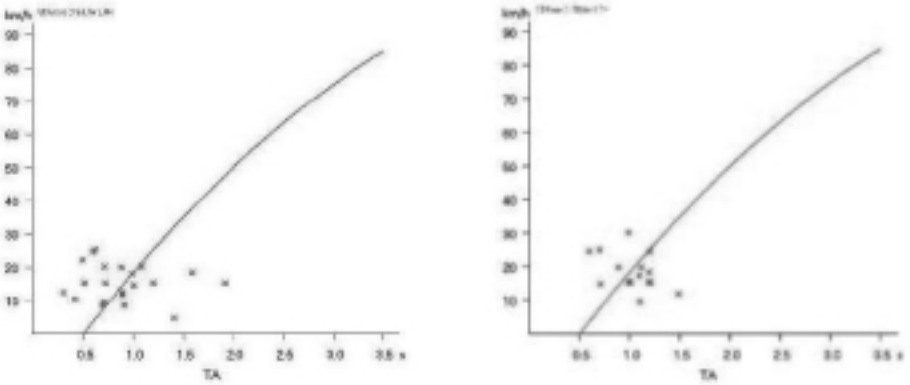


Figure 4. Proportion of two step left turn bicycle

The chart below shows the total number of conflicts at the junction has declined from 22 to 16 after implementing the countermeasure. Among them, the number of serious conflicts has declined from 12 to 5, the proportion of serious conflicts also has declined from 55 percent to 31percent (the data were from peak hours and taken by video).



Before

After

Figure 5. Before and after comparison - conflicts

The mean speed and 85-percentile speed of right turn vehicles were also reduced after implementing the countermeasure. It is mainly because the volume of bicycles stopped at the waiting line made the space for right turn vehicles smaller and thus slows the vehicles down or even makes them stop. Consequently, it improves the VRU's safety.

Table 2. speed before and after comparison - speed of right turn vehicles

	Before	After
Mean speed	16.5 km/h	15.4 km/h
85% speed	22 km/h	20.7 km/h

Note: the speed is getting in the peak hours and sample size is 100 right turn vehicles.

5.2 Set signal for right turn vehicles

Problems: The volume of right turn vehicles is high, and vehicles turn right on red without giving way causes lots of conflicts with through bicycles and pedestrians.

Objectives: Reduce the conflicts between right turn vehicles and bicycles or pedestrians.

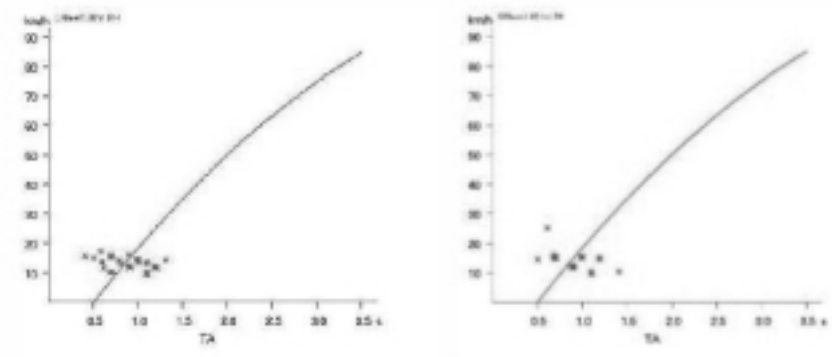
Example: Dawang

Outcome: The pictures of before and after at the junction are shown as below.

Before After

Figure 6. Before and after pictures

After setting the signal for right turn vehicles, the total number of conflicts declined from 32 to 19, the number of serious conflicts declined from 14 to 7. The proportion of serious conflicts also declined from 44 percent to 37 percent. Since there was no interruption of vehicles from west to east after setting the signal, the speed of right turn vehicles actually could increase (the conflicts were gotten by video in peak hours).



Before After

Figure 7. Before and after comparison - conflicts

By setting the signal for right turn vehicles, the conflicts between right turn vehicles and go through pedestrians can be effectively reduced, while the speed of right turn vehicles could be increased when traffic signal is green. . The movement of bicycles has also increased as having free flow when right turn vehicle signal is red. Therefore, it is recommended to set the right turn vehicle signal in combination of bicycle through signal to separate the flows and move them in turns at the junctions where there is a separate lane for right turn vehicles.

5.3 Install leading signs and barrier to guide pedestrians using existing facilities

Problems: Pedestrians are requested to use either a fly-over bridge or underpass when crossing the street on the Changan street. However, without a traffic assistant in place, some people still across the street on the ground.

Objectives: Discipline pedestrians' behaviour, guide pedestrians crossing the street to use the existing underpass or fly-over bridge, and reduce the risk of pedestrian crashes and conflicts.

Example: Xidan

Outcome: The pictures of before and after at Xidan are shown as below.

Before After

After After

Figure 8. Before and after pictures

Installing leading signs and barrier to guide pedestrians to use theunderpass changed pedestrians°Ø behaviour. The outcome of our post-intervention survey shows that the number of pedestrians crossing the junction on the ground declined from 27 to 12 per hour in peak hours, which resulted in reducing the risk of pedestrian crashes and conflicts with motor vehicles at the junction.

5.4 Install refuge islands for pedestrians

Problems: The junctions are too big for the pedestrians to cross in one stage.

Objectives: Provide pedestrians a safe space to wait for a second stage crossing, and reduce conflicts between the vehicles and pedestrians.

Example: Dongsi Shi Tiao

Outcome: Before and after pictures at Dongsi Shi Tiao are shown as below:

Before After

Figure 9. Before and after pictures

By installing the refuge island at the junction, 79 percent of the pedestrians feel much safer when crossing the street (the survey sample size wa 200). The post-intervention survey shows that 89percent of pedestrians use the refuge island to cross the junction in peak hours. The average walking speed of a person reduced from 1.3 m / sec to 0.9 m / sec. They felt more relaxed when crossing (data in peak hours).

5.5 Modify the length, locations and radian of the barriers at the roundabout

Problems: The barriers segregating bicycles from motor vehicles were set inappropriately; therefore, only few bicyclists used the lane setting for bicycles.

Objectives: Increase the compliance rate with traffic laws for bicyclists by getting them to use the bicycle lane to improve their safety on the road, and reduce the number of conflicts between bicycles and motor vehicles.

Example: Dongsi Shi Tiao (roundabout)

The picture below shows the roundabout is divided into 6 sections.

Figure 10. The 6 sections of the roundabout

Specific Countermeasures:

- make the bicycle lane one meter wider at the section 1
- change the guiding line at entrances from an arc shape into a straight line at the section 1 and 3
- a nine-meter barrier has been installed to segregate the bicycles and motor vehicles between the sections 1 and 6.

Outcome: By taking the above countermeasures, the compliance rate of bicyclists has been increased at most of the sections (data in peak hours).

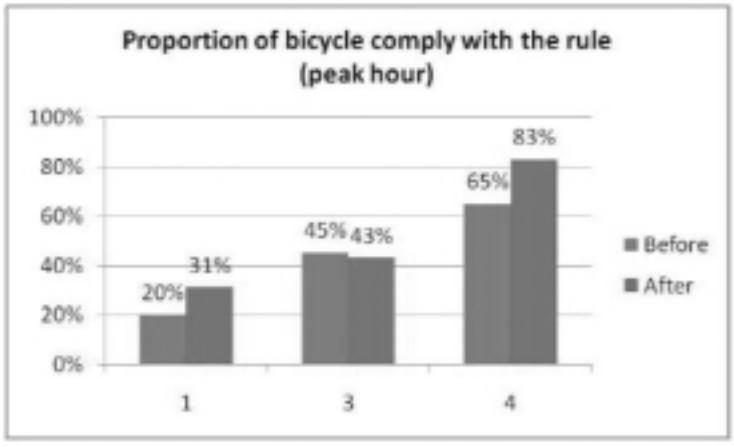


Figure 11. Before and after comparison - traffic law compliance rate at peak hour

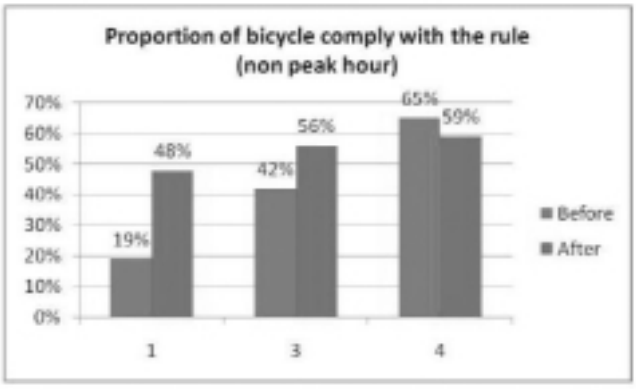


Figure 12. Before and after comparison - traffic law compliance rate at non-peak hour

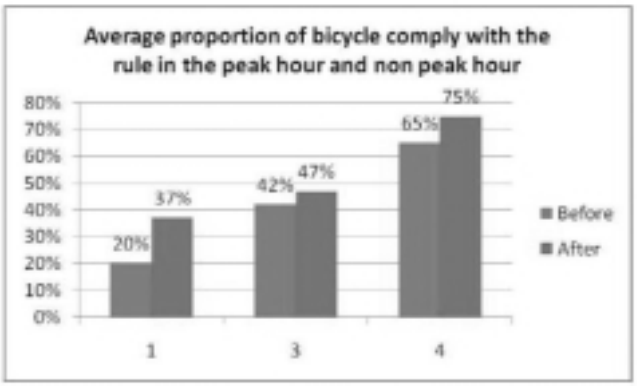


Figure 13. Before and after comparsion - average

5.6 Improve the situation of bus station

Problems:

a) The bus stop at the north exit was located very closely to the junction, and many buses stopped there.

b) There was a high volume of passengers either waiting there for the other bus or crossing to transfer to the subway.

Objectives: Reduce the conflicts between alighting passengers and bicyclists, and guide passengers using the zebra crossing line on the road.

Example: Da Wang

Specific Countermeasures:

- Build a 60 meters long platform to reduce the conflicts between alighting passengers and bicyclists
- Set the median barriers to guide people using zebra crossing line when crossing the junction;
- Paint a zebra crossing line between the bus stop and sidewalk

Outcome: Before and after pictures at the junction are shown as below.

Before After

Figure 14. Before and after pictures - moving the location of the bus stop

After

Figure 15. After pictures - setting the median barriers

By setting the median barriers, 95 percent of passengers cross the street via the zebra compared with the previous 35 percent. After setting the zebra crossing line between the bus stop and sidewalk, 43 percent of passengers use the zebra crossing when they get off the bus

6. Discussion and Conclusions

Through the before and after analysis of the countermeasures, it can be clearly seen that the safety of VRU has been improved at the selected six junctions in Beijing. However, it is worth mentioning that the countermeasures used in the project are neither expensive nor unique - they are routine work for the local traffic police. What makes the project unique are:

a) Multi-sector cooperation. The project involved the appropriate government agencies, an academic institution and an international road safety agency. The local partners played a crucial role to the success of the project and merits of each party were fully used in the project.

b) The project was carried out in a systematic and scientific manner. Evidence based decision making and the before/after data comparison are the highlights of the project. It has proven that low cost engineering countermeasures can effectively improve road safety for VRUs.

However, what have been implemented at each selected intersections are only the beginning of the long process, there still are a lots of room for continuous improvement. With more implementation the team believes experience will show even more reductions in the risk factors being evaluated.

As a output of the project, the local project team developed a good practice manual - Design & Operational Guide on Vulnerable Road User Safety at Junctions based on international and national good practice in VRU safety and experience gained from the project. The manual aims to provide a design and operational guide for reducing conflicts and improving the safety situation of VRUs at urban junctions, whilst taking account of traffic efficiency. It introduces the relevant road and facilities design, as well as management countermeasures. The manual will be published in both Chinese and English. We hope it will be used as a reference book by leaders and professionals in road safety related government agencies, road design and traffic engineering institutions, traffic management divisions, and relevant research institutes and universities.

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