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Safe Routes to Transit in Developing Cities

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Abstract

Poor quality pedestrian infrastructure and inadequate transit services have led to the continued loss of mode share for walking and public transit trips in developing-nation cities. However, the success of Bus Rapid Transit (BRT) systems in cities such as Bogotá (Colombia) and Curitiba (Brazil) has shown that such trends can be reversed. This research highlights the nexus of high-quality pedestrian access and BRT systems as a mechanism to preserve the viability of public transport in developing cities. Specifically, the research presents:

- A discussion of walking conditions at transit stations
- Infrastructure options for ensuring safe access to transit
- Methodologies for mapping pedestrian movements
- Key elements of pedestrian safety, including vehicle speeds, exposure risk, driver and pedestrian predictability, and vehicle volumes
- Best and worst practices from cities in Latin America, Asia and Africa.

The rapid increase in BRT development across the developing world provides a unique opportunity to improve the overall situation for pedestrians. The condition of the walking environment to and from BRT stations will ultimately determine the viability of the BRT system to draw a sufficient customer base. The investment towards BRT and the changes in street infrastructure can provide an impetus for area-wide improvements.

The research presented is based upon a new initiative sponsored by the Hewlett Foundation and the Global Environment Facility in order to enhance walking and public transit trips in developing-nation cities.

Biographies

Michael King is an architect working at the intersection of transportation and urban design. He leads the New York office of Nelson\Nygaard, holds degrees from Washington and Columbia Universities, and has worked on walking, cycling and traffic calming projects in Africa, Asia, Europe, North America, and South America.

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INTRODUCTION

Public transport systems should not be designed and implemented in isolation. By optimising a transit system's interface with other modal options, system designers are helping to maximise the potential customer base. A public transport system does not end at the entry or exit door of the station, but rather encompasses the entire client capture area. If customers cannot reach a station comfortably and safely, then they will cease to be customers.

Access by foot to public transport is particularly key in the developing world. The poor pedestrian conditions in developing cities effectively inhibit the use of public transport, even in areas with limited viable alternatives. The lack of adequate pedestrian connectivity to stations contributes to unrealised trips and ultimately to shifts to motorised vehicles. Mode shares for both walking and public transport are generally declining throughout the developing world (WBCSD, 2001). In developed nations, planners may seek to provide reasonable pedestrian access within a 500 metre radius of a transit station. In the developing world, transit passengers may walk considerably longer distances to public transport stations – there is evidence in South Africa that people walk up to four kilometres to reach a train station.

This research examines the quality of existing pedestrian routes to public transport systems in developing-nation cities. The research particularly focuses upon pedestrian access to bus rapid transit (BRT), which shows much promise to deliver high-quality mass transit to developing-nation cities. BRT is a low-cost mass transit option that emulates the amenity features of rail-based systems but at a fraction of the cost (Wright, 2004). BRT systems vary depending on local circumstances, but typical features include:

- Segregated, median busways
- Pre-board fare collection and fare verification
- Restricted operator access based on competitive tendering
- Free transfers between corridors
- High-frequency services
- Clean vehicle technologies
- Modal integration with feeder vehicles, pedestrians, bicyclists, taxis, and private vehicles

To date, good quality BRT systems have been developed for such cities as Bogotá (Figure 1), Curitiba, Jakarta (Indonesia), León (Mexico), Quito (Ecuador), São Paulo (Brazil), and Seoul (South Korea). This research is part of an effort supported by the Global Environment Facility and the Hewlett Foundation to improve knowledge of best-practice BRT in developing-nation cities. While the focus of the research is on access to BRT systems, the lessons learned are also of relevance to other public transport systems such as rail-based systems and local busses.

Figure 1 The Bus Rapid Transit (BRT) system in Bogotá (Colombia). Photo by Manfred Breithaupt, GTZ photo CD (www.sutp.org).

EVALUATION FRAMEWORK FOR TRANSIT ACCESS

To evaluate the quality of pedestrian access to public transport, an evaluation framework has been devised (Table 1). Specifically, effective transit access is achieved with infrastructure that is affordable, attractive, comfortable, direct, legible, safe, and secure. If any one of these categories are not adequately addressed, then the entire viability of transit access can be undermined.

Table 1 Evaluation Framework For Transit Access

Category	Description
Affordability	The cost of providing transit access is greatly affected by the need for pedestrian bridges, underpasses, and other significant infrastructure.
Aesthetics	The aesthetics of the pedestrian access area encompasses the attractiveness of the walkway, the street furniture, and the congruence between street design and local architecture.
Comfort	Issues of "comfort" include steepness of inclines, weather protection, condition of walking surface, and protection from noise and air pollution.
Directness and connectivity	"Directness" involves a pedestrian path that minimises the distance travelled to access the transit station. Connectivity refers to the ability of pedestrians to readily access a broader network of destinations.
Legibility	The legibility of an area refers to the ease in understanding the street environment. The availability of maps and signage can help legibility.
Safety	A "safe" pedestrian pathway implies that pedestrians are well protected from road hazards such as vehicles.

Security	"Security" refers to providing an environment where pedestrians are not susceptible to robberies or other crimes.

These qualities are not necessarily always mutually compatible. For example, the most direct path may involve conflicts with vehicles, or the safest route may imply using a difficult set of stairs. The design challenge is to prioritise competing interests while balancing the outcome. This paper highlights the safety component of this evaluation framework.

TRANSIT ACCESS AND PEDESTRIAN CONDITIONS IN DEVELOPING CITIES

The developing-nation pedestrian runs a gauntlet of challenges that directly contribute to the high injury and fatality rates witnessed in these countries. These challenges include the following:

- Complete lack of pedestrian pavements
- Poor quality of pavements, often dirt or mud
- No physical separation from high levels of traffic and from high-speed traffic
- Extreme levels of noise and air pollution
- Lack of infrastructure to permit crossing of street
- Obstructed pavements due to parked cars (illegal or legal), poor design, utility poles and signs, uncollected rubbish, etc.
- No protection from harsh climatic conditions
- Lack of pedestrian support infrastructure such as street lighting
- Pedestrian overcrowding due to narrow or below-capacity pavements
- High levels of robbery, assault and other crime befalling pedestrians

Adapted from Vasconcellos (2001, p. 113) and Hass-Klau et al. (1999, p. 105)

The complete lack of formal pedestrian pavements in developing nations is relatively common. Hook (2003) notes that: "Over 60% of the roads in Jakarta, for example, have no sidewalks, and those that exist are heavily obstructed by telephone poles, trees, construction materials, trash, and open sewer and drainage ditches." Likewise, in African cities, poor districts will rarely be provided with pedestrian infrastructure, even though virtually all of the population of such areas do not own a motorised vehicle.

Crossing a street can be particularly difficult in developing-nation cities due to a lack of formal crossings and restrictions on informal crossings, with the latter typically based on driving and not walking patterns (Figure 2). In some instances pedestrian overpasses or underpasses are provided, but pedestrians often eschew such infrastructure because they do not serve their needs. Pedestrian overpasses and underpasses in developing-nation cities are often either filled with informal merchants or inherently dangerous from a crime and safety standpoint. Not surprisingly, many people (in all parts of the world) choose to take their chances crossing through the chaotic and dangerous maze of traffic. Vasconcellos (2001) also notes that even when crossings are provided, they rarely give priority to the pedestrian:

> "Crossing facilities are also inadequate; zebra crossings are rare, and signals rarely consider pedestrian needs; in such cases, pedestrians are seen as something that might be 'stacked' until some gap is available in the traffic stream: 'second class citizens' have to wait until first class ones exert their rights to use roads."

Figure 2 The lack of formal pedestrian crossings in Dhaka (Bangladesh) create significant risks. Photo by Karl Fjellstrom.

The poor pedestrian conditions in developing-nation cities can result in pedestrian trip distances that are considerably longer than those endured by motorised vehicles. Hook (2000) documents how sidewalk barriers and other detours in Surabaya result in substantially longer journeys for pedestrians:

> "…pedestrian barricades and one way streets have been used to facilitate long distance motorised trips but which simultaneously impose huge detours for short distance cycling and pedestrian trips. People wishing to cross a main shopping street often find it easier to take a taxi two kilometres than to walk across the street. In Surabaya, the World Bank estimated that these measures generate an additional daily 7000 kilometres of needless vehicle traffic."

A new mass transit system offers the opportunity to re-evaluate pedestrian conditions and develop a vastly improved pedestrian environment. However, the development of a new BRT system involves a myriad of design, financing, and infrastructure issues. The importance of pedestrian access can easily be forgotten against the backdrop of a complex project. Some of the initial efforts with the Jakarta BRT system have failed to properly address pedestrians (Figure 3). However, Jakarta is now responding to some of its early problems and embarking on a re-design of pedestrian facilities in the next phases of the BRT network.

Figure 3 Pedestrian Infrastructure of the new BRT System in Jakarta. Photo courtesy of ITDP.

MAPPING AND DATA COLLECTION

Any city developing a BRT access plan will be well served to conduct basic survey and mapping exercises. This information will lead to more informed decision-making in terms of the type of pedestrian infrastructure required to facilitate safe and effective access to transit.

In terms of realising a safer pedestrian environment around transit, a starting point is often the crash history of the area. Simply put, locations with high crash rates are not safe for a transit station, unless mitigation measures can be installed to improve conditions. Even though the numbers are likely to be significantly underreported, a simple mapping exercise should make it possible to identify particularly dangerous locations.

Figure 4 shows pedestrian volumes along the first BRT corridor in Jakarta and compares these results with injury locations. This comparison was used to demonstrate that higher pedestrian volumes are not necessarily accompanied by more deaths and severe injuries. In fact, vehicle speed was the most representative indicator of injury severity. Pedestrian volumes usually mean more absolute numbers getting hit, but generally with less severe outcomes. This “safety in numbers” argument is gaining currency within pedestrian safety community.

Figure 4 Pedestrian volumes, injuries and deaths along a BRT Corridor in Jakarta. Images courtesy of ITDP.

A basic assessment of existing conditions also helps to identify potential problem areas. Such an analysis can be accomplished with just a basic set of tools (e.g. a good map, a camera and a measuring wheel). In the following image from Surabaya (Figure 5), pedestrian paths and crossings have been rated usable (green), partially usable (yellow) and unusable (red).

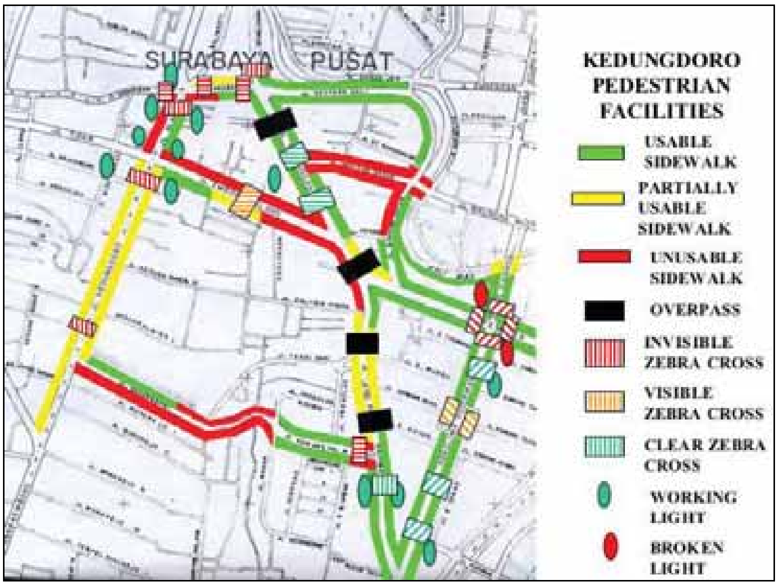


Figure 5 Pedestrian facility evaluation in Surabaya. Image courtesy of ITDP.

On the micro scale, a pedestrian tracking survey is a useful tool to document exactly how people use a street or intersection. These surveys have been used to redesign intersections, show how the space is used throughout the day, and demonstrate a specific pattern (such as a need for a crosswalk). Figure 6 illustrates a pedestrian tracking survey at a complicated intersection in New York City.

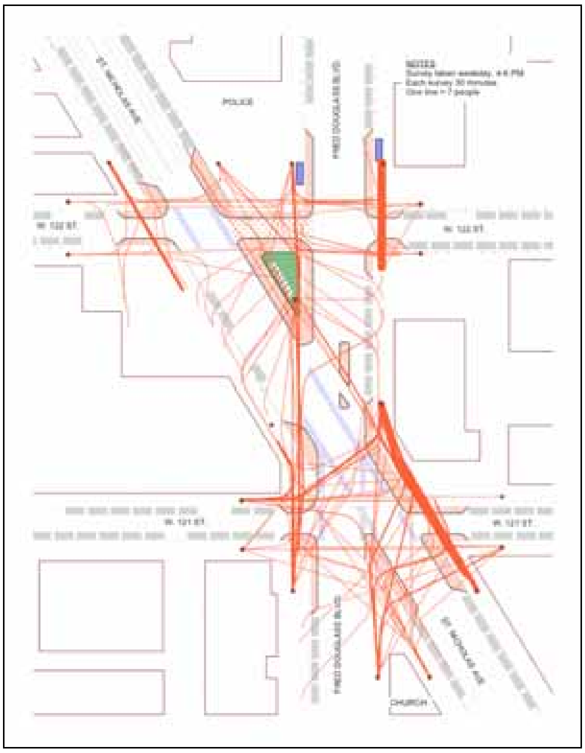


Figure 6 Pedestrian tracking survey in New York City. Image by Michael King.

KEY ELEMENTS OF PEDESTRIAN SAFETY

There are four fundamental elements to pedestrian safety along any roadway. These concepts are equally applicable at BRT stations and elsewhere. The physical factors (sidewalks, crosswalks) and actors (walkers, drivers) are constants in both environments.

- Vehicle speed. Vehicle speed is a significant determinant of crash severity and often dictates the nature of a street. As vehicle speed increases, so does risk to drivers and pedestrians; increased speeds must be accompanied by additional physical separations or impact protections. As speed decreases, the range of design options expands.

- Pedestrian 'exposure' risk. This is the time that pedestrians are exposed to traffic; it has both a temporal and spatial component. To reduce exposure risk is to increase safety.

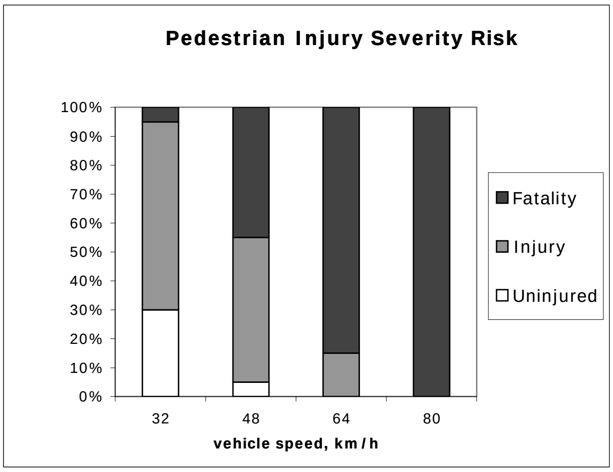
- Driver and pedestrian predictability. Drivers are constantly making decisions, and if other street users – walkers, cyclists and other drivers - can better predict those decisions, then the street will be safer. Reducing the number of options for drivers at key junctures is the simplest way to improve driver predictability.

- Vehicle volume. A street with zero cars will see zero auto-related incidents. Every additional vehicle in the street increases the possibility of incident with pedestrians, until there are so many vehicles that people are banned, like on an expressway.

Vehicle Speeds

The relationship between vehicle speeds and the risk of death or injury has been well documented in a range of settings (Table 2). At speeds of less than 32 km/h there are almost no pedestrian deaths; at 80 km/h all vehicle-pedestrian incidents result in death. There is good reason why residential speed limits in countries with good traffic safety records are set at 30 km/h or less.

Table 2 Relationship between Vehicle Speed and Pedestrian Safety (UK DOT, 1993)



Similarly, research from Australia suggests that a drop in speed of only 5 km/h will result in:

- 10% fewer pedestrian fatalities; and
- 20% less severe pedestrian injuries (Anderson, 1997)

There are many techniques to lower traffic speeds, from speed limits to police enforcement to physical design. Traffic calming has had good success in the last 30 years improving safety. Measures include:

- Speed humps ('sleeping policemen') slow drivers
- Raised crosswalks slow drivers at designated pedestrian crossing location
- Curb extensions at intersections force slower turning speeds
- Restructuring roads to meander around trees, planters and medians forces drivers to slow down
- Changing from smooth to rough road surfaces or using rumble strips alerts drivers to a change in roadway condition

Exposure Risk

There are a few fundamental ways to reduce exposure risk when crossing the street. The roadway can be narrowed, either entirely or at specific points via curb extensions. Pedestrian refuge islands can be added, permitting pedestrians to wait in the middle of the street. Traffic signals can be altered to provide additional time for pedestrians to cross the street. The phasing of traffic signals can give walkers priority over vehicles, such as prohibiting turns on red signals or using an exclusive phase for pedestrians and cyclists to cross.

A novel technique is the leading pedestrian interval (LPI). An LPI re-times the signal phasing so that the pedestrian phase begins a few seconds before the vehicular phase. Typically, this permits a pedestrian to get halfway across the street and establish presence in the crosswalk before vehicles start turning, thus increasing the chance that drivers will yield as required (Figure 7). The image on the left below shows the pedestrian phase of an LPI . The image on the right shows the pedestrian plus vehicle phase; all of the pedestrians have cleared the intersection.

Figure 7 Pedestrian and vehicle phases of a leading pedestrian interval (LPI) in New York City. Photos by Michael King.

An analysis of 10 years of crash data from New York City shows that intersections with LPIs have 26 percent fewer pedestrian injuries and those injuries are 36 percent less severe (King, 1998). Data from San Francisco (USA) show that 89 to 98 percent more drivers yielded to pedestrians after LPIs were installed (Fleck, 2000). Data from St. Petersburg (USA) show that 95 percent more drivers yielded to pedestrians after LPIs were installed (Van Houten, 2000).

Another fundamental decision affecting pedestrian crossings at transit stations is whether to provide at-grade entry (crosswalks) or grade-separated entry (overpasses and tunnels). In general, pedestrians will prefer at-grade crossings due to the directness of the access. Typically, pedestrian overpasses increase access time and thus are not used by pedestrians. A 1965 study found that if crossing via the overpass takes 50 percent longer than crossing at grade, then almost no one will use the overpass. Usage of underpasses (tunnels) was even less (Moore and Older, 1965). The fatal flaw of most pedestrian bridges is that, while they may have been built for the 'safety' of pedestrians, they are hardly usable by frail people or those pushing baby strollers – exactly the audience they were intended to protect. Transportation professionals are increasingly suspect of pedestrian bridges and tunnels that are not integrated into the surrounding infrastructure.

However, where vehicle speeds and traffic levels dictate, pedestrian overpasses can be a necessity. The Bogotá BRT system's modern pedestrian ramps serve as a good example of providing functional and aesthetically pleasing overpasses (Figure 8). To enter the overpass, Bogotá provides a ramped entry with a sufficiently gradual slope to ease the climb. Utilising a 2.5 metre-wide pedestrian space and an open design, Bogotá's pedestrian bridges alleviate many of the security concerns normally associated with overpasses.

Figure 8 Pedestrian bridge at BRT Station in Bogotá. Photo courtesy of TransMilenio SA.

Driver and Pedestrian Predictability

Design elements that encourage more predictable movements from both drivers and pedestrians can result in reduced conflicts. Techniques to increase predictability can include dedicated turn lanes, traffic islands (which double as pedestrian refuge islands and may take the form of a BRT station), curb extensions (which prevent drivers from passing on the curb side), narrow lanes (which prevent double parking), medians (which prevent sudden turns), and good sight distance (so everyone knows what everyone else is doing).

There are many solutions to providing safer and more effective pedestrian crossings at transit stations. The design of the crossing itself will play a role. The areas to the side of the roadway should allow for clear visibility, so that the sight lines for both pedestrians and vehicle users are unimpeded by signage or vegetation. The crossing’s painted surface should be highly visible and well maintained. Luminescent paints or reflectors can provide additional visibility for evening hours. Additionally, high illumination street lighting should be placed over the crossing area. In contrast, signage and advertisements can create an area of visual clutter that will distract motorists from seeing traffic signals and pedestrians properly, and should be avoided to the extent possible.

The following images are of the same pedestrian refuge island in Guangzhou (China). The one on the left is shown without lighting. Note that the driver cannot tell if there are people waiting or in the crosswalk. The one on the right is shown with sufficient lighting (Figure 9).

Figure 9 Pedestrian refuge island, with and without lighting, Guangzhou. Photos by Michael King.

At-grade crossings should be placed as close to the station entrance as possible. Otherwise, customers may simply cross at another point closer to their intended destination. Figure 10 shows a crossing some 100 meters away from a BRT station. Some customers must walk 100 metres down the road and then return to access a point that is about 12 metres from their starting point.

Figure 10 A crosswalk that is over 100 metres away from a BRT station in León (México). Photo by Michael King.

The likelihood of compliance with pedestrian signalisation is significantly reduced if wait times exceed 30 seconds (Table 3). In a similar fashion, elevators are generally designed so that people do not have to wait more than 30 seconds. The concept of pedestrian delay applies primarily to traffic signals, but also to gaps in traffic and crosswalk location. Where there are no signals, pedestrians generally must wait for a “gap” in traffic to cross the street. If the flow of traffic is so great that sufficient gaps are not available, then the person afoot will attempt to cross the street dangerously.

Table 3 Pedestrians Patterns per Delay (TRB, 2000)

<table>
<tr><th>Pedestrian Delay (seconds)</th><th>Likelihood of Non-compliance</th></tr>
<tr><td><10</td><td rowspan="2">Low</td></tr>
<tr><td>10-20</td></tr>
<tr><td>21-30</td><td>Moderate</td></tr>
<tr><td>31-40</td><td rowspan="2">High</td></tr>
<tr><td>41-60</td></tr>
<tr><td>>60</td><td>Very High</td></tr>
</table>

Excessive delay at BRT stations can produce negative results for several reasons. First, customers have a tendency to rush to catch an approaching bus or train (Figure 11). While frequent services mitigate this tendency, customer care in crossings can be compromised when persons are in a hurry. Second, vehicles in mixed traffic lanes may be less prepared for the existence of mid-block (non-intersection) crossings placed to serve a transit station. Inattentive drivers may not realise a crossing exists and may fail to properly yield to pedestrians or to obey mid-block traffic lights. Thus, the combination of pedestrians focusing on their bus and inattentive drivers can produce lethal consequences.

Figure 11 Rushing to the bus stop in Quito. Photo by Lloyd Wright.

Vehicle Volume

The safest pedestrian access route is one completely segregated from motorised vehicles. Thus, car-free pedestrian paths that connect to transit stations represent an ideal from a safety perspective. The pedestrian zones in Curitiba provide an example of how integration between car-free areas and public transport systems are mutually beneficial (Figure 12). The pedestrian zones improve the financial viability of the BRT system by essentially acting as high-volume feeder services into the transit system. The BRT system helps alleviate the necessity of costly car-based infrastructure in the city core, and thus opens up public space for the pedestrian zone.

Similarly, the extensive cycle way network in Bogotá is quite complementary to the BRT system. The cycle way essentially extends the customer catchment area for the BRT system. Secure bicycle parking facilities at Bogotá's BRT terminals provides the supporting infrastructure to make bicycle-transit integration viable.

Figure 12 Integration of pedestrian zones with BRT in Curitiba. Photo by Lloyd Wright.

SHARED SPACE

The previous discussion on segregated pedestrian infrastructure must be tempered by a new concept known as "post traffic calming" or "shared space". With shared space, all physical differentiation between car space and pedestrian space is removed (Figure 13). In other words, there are no lane markings, crosswalks, signals, or curbs. For many, the idea of shared space seems counter-intuitive: "Build roads that seem dangerous, and they'll be safer" (McNichol, 2004). The idea is that the lack of signage and road markings increases the uncertainty for motorists, who will then be more cautious within an undefined road environment. Through intrigue and uncertainty motorists become more engaged in their surroundings (Engwicht, 1999).

A monotonous roadway with high dosages of signage and markings increases speeds and lowers driver awareness, which is a combination inviting accidents. In an area of shared space, neither pedestrians nor motorists have explicit signage to dictate who has priority. People must resort to eye contact and other forms of subtle communication to navigate the roadway. The end result is that motorists instinctively reduce speeds in order to engage in this subtle communication process.

The origins of shared space are attributed to Hans Monderman of the Netherlands who has taken his designs to roadway intersections of such Dutch cities as Drachten and Oosterwolde. In a short amount of time, these concepts have made their way to a variety of other locations including Christianfield in Denmark, Wiltshire and Suffolk in the UK, and West Palm Beach and Cambridge in the US. In each case, improvements in safety have been recorded.

Creating a network of shared spaces as a way to improve pedestrian safety and access to BRT stations holds genuine possibility. Yet while the lack of signage results in greater caution from motorists in the Netherlands, it is not clear if the same success would be achieved on the streets of Lagos, Jakarta, or São Paulo. Further, as traffic or BRT volumes increase, there may be a point where the transit system's performance will be affected. Nevertheless, Bogotá has included some elements of shared space on its Alameda Jimenez corridor.

Figure 13 Shared space concept as applied in Guangzhou. Photo by Karl Fjellstrom.

CONCLUSIONS

Ensuring that a public transport system is well integrated with pedestrian infrastructure is critical to developing a truly usable system. The difference between a pleasant and safe walking environment and a poorly maintained pedestrian path can be the difference between customers choosing public transport over other options. Thus, the quality of the integration infrastructure is one of the determining factors in ridership and customer satisfaction. Ultimately the goal is to create a safe and accessible route to each station.

Improving the transportation infrastructure around a BRT station will not only benefit passengers, but also all pedestrians frequenting the area. The pedestrian improvements being made in conjunction with BRT systems in cities such as Bogotá, Curitiba, Jakarta, and Quito may well leave a legacy beyond the delivery of much needed mass transit.

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