ITDP
Institute for Transportation & Development Policy

SAFE ROUTES TO TRANSIT

BUS RAPID TRANSIT PLANNING GUIDE

PEDESTRIAN SECTION

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Table of Contents

Overview **1**

Safety **2**
- Key Elements of Pedestrian Safety 2
- Crash History 9

Accessibility **19**
- Physical Conditions 19
- Quality of Pedestrian Experience 21

Connectivity **25**
- Service Zones 25
- Origin-Destination Analysis 26
- Transfers to Other Modes 28

Appendix A: Documenting Sidewalk Conditions

Appendix B: Kansas City Pedestrian Level of Service Model

Appendix C: Pedestrian Bridges And Underpasses

SAFE ROUTES TO TRANSIT

BUS RAPID TRANSIT PLANNING GUIDE – PEDESTRIAN SECTION

OVERVIEW

A key component of BRT station planning and design is the provision of safe, convenient and secure access for pedestrians. If it is not convenient or easy to walk to a BRT station, then customers will be discouraged from using the system. Providing a Safe Route To Transit is therefore the first step to providing an effective BRT service.

While station locations vary by the origin/destination patterns to be served and local context, fundamental pedestrian factors remain constant. These include:

- Safety
- Security
- Directness
- Ease of entry
- Comfort
- Aesthetics

A "safe" pedestrian pathway implies that pedestrians are well protected from road hazards such as vehicles. "Security" refers to providing an environment where pedestrians are not susceptible to robberies or other crimes. "Directness" involves a pedestrian path that minimises the distance travelled. "Ease of entry" means that the walk to the station does not involve onerous actions, such as walking up steep inclines. "Comfort" refers to the quality of the pathway and provisions for protection from inclement weather, such as sun, wind and rain. "Aesthetics" imply that the walking environment is pleasing to the eye and inspires a person to use public transport.

Project Description

Nelson\Nygaard was retained by the Institute for Transportation and Development Policy to update and augment the Pedestrian Section in their Bus Rapid Transit Planning Guide. The work was funded by the Hewlett Foundation and the Global Environment Facility and builds on a previous guide prepared by the German Technical Assistance Agency (Deutsche Gesellschaft für Technische Zusammenarbeit). The work was completed in 2005 with Michael King as the principal author.

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 climbing over a difficult set of stairs. The design challenge is to find a balance that optimises the total package of characteristics.

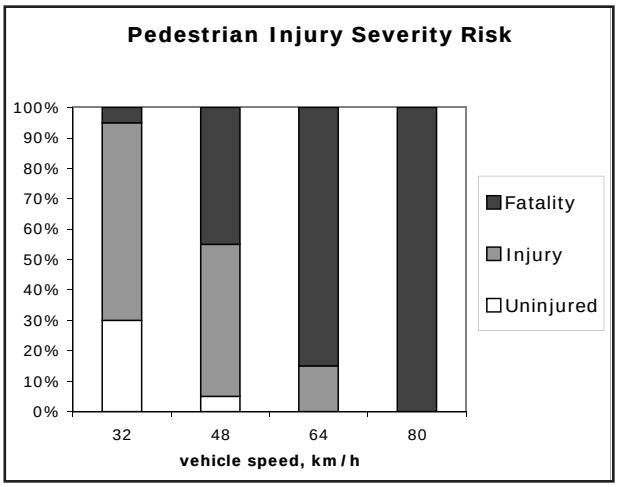
This section of the manual addresses pedestrian access and safety. It is organized according to three broad themes: safety, accessibility and connectivity. Safety pertains not only to that of pedestrians, but to an environment where motor vehicles do not dominate the urban fabric. For example there are "safe" places with few vehicle-pedestrian conflicts, but only because there are few pedestrians. Accessibility covers not only issues for those in wheelchairs, but also the general possibility of walking to the BRT station. Security is placed here, for if the route is not secure, then it is not accessible, even with wheelchair ramps. Connectivity discusses the placement of the station within the larger context of the urban fabric.

The notion of safe foot access to a BRT station is not an isolated concern. Many of the issues are neither pedestrian nor transit specific. The following elements have universally application yet can be tailored to this subject.

Key Elements of Pedestrian Safety

There are four fundamental aspects to pedestrian safety along any roadway. These concepts are equally applicable to pedestrian safety when accessing BRT stations, as the physical factors (sidewalks, etc.) and decision-makers (walkers, drivers, etc.) are constant in both environments.

- **Vehicle speed.** Vehicle speed is a significant determinant of crash severity and often dictates the nature of a street including the pedestrian facilities and accessibility to a transit station. 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 and so do options for pedestrians.
- **Pedestrian 'exposure' risk.** This is the time that pedestrians are exposed to the dangers of traffic and has both a temporal and spatial component. Crossing distances and crossing times at signalized intersections are key indicators of exposure risk, as are vehicle speeds and volumes. To reduce the exposure risk is to increase safety.
- **Driver predictability.** Drivers are constantly making decisions, and if other street users - drivers, cyclists, or pedestrians - 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.



Relationship between Vehicle Speed and Pedestrian Safety
Source: "Traffic Calming Regulations: Traffic Advisory Leaflet 7/93," United Kingdom Department of Transport Traffic Advisory Unit, 1993.

- **Vehicle volumes.** 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 chart above graphs the relationship between vehicle speed and pedestrian injuries in the United Kingdom. At 32 km/h about 30% of collisions between vehicles and pedestrians will result in no injury, 65% in injuries and 5% in fatalities. As vehicle speed increases the percentage of fatalities increases so that by 80 km/h all vehicle-pedestrian incidents result in death.

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.[1]

1 McLean, A. et al., "Vehicle Travel Speeds and the Incidence of Fatal Pedestrian Collisions," Accident Analysis and Prevention, Vol. 29, No. 5, 1997.

There are many techniques to lower traffic speeds, from speed limits, to police enforcement, to physical design. This section highlights a few of the design options, commonly known as *verkehrsberuhigung*, or traffic calming.

- 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

The images below show techniques which decrease speeds thereby creating safer conditions for pedestrians.

Courtesy Michael Ronkin

Curb extension – *before*
Salem, Oregon (USA)

Courtesy Michael Ronkin

Curb extension – *after*
Salem, Oregon (USA)

Michael King

Raised crosswalk
Morogoro Road, Tanzania

Michael King

Speed humps
Mexico City, Mexico

Michael King

Fence in center of road keeps drivers from swinging wide during turn
Shenzhen, China

Michael King

Roundabout
Cape Town, South Africa

Exposure Risk

There are a few fundamental ways to reduce exposure risk when crossing the street. One can narrow the roadway, either overall or at specific points via curb extensions. One can add traffic or pedestrian refuge islands where people may wait in the middle of a two-way street. One can alter traffic signals to provide additional time for pedestrians to cross the street. One can alter the phasing of a traffic signal to give walkers priority over vehicles, such as prohibiting right turns on red signals or using an exclusive phase for pedestrians and cyclists to cross.

Altering driver behavior also can decrease exposure risk. For example, lower speeds and speed humps create longer 'gaps' between passing cars and hence a longer time for people to cross the street. Lower speeds increase reaction times, which means people have more time to react.

Michael King

A series of medians and islands breaks up the crossing and keeps drivers in their proper lanes.
Mexico City, Mexico

Michael King

Bollards placed in the roadway narrow the intersection and force drivers to turn a slower speeds.
Berlin, Germany

Driver and Pedestrian Predictability

Driver predictability can best be explained through the differences between limited-access highway and city street design. Highways generally have what is known as 'recovery zones'- an area alongside the road or just after an exit ramp where drivers who have had an accident or missed the turn can take corrective action before hitting a tree or other obstacle. The penalty for a flat tire should not be a severe crash.

Urban streets usually have sidewalks adjacent to the roadways and people waiting to cross the street at the corner; no 'recovery zone' is available. Techniques to increase driver predictability in these contexts 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 right), narrow lanes (which prevent double parking), medians (which prevent sudden turns), and good sight distance (so that everyone can know what everyone else is doing).

Pedestrians should be protected from errant drivers through physical obstructions, such as bollards, trees, and parked cars. Placing bollards to protect curbs at intersections prevents trucks and motorists from jumping curbs and hurting pedestrians. Bollards also are used to prevent motorists from parking on sidewalks. The images below show how the median can be altered to increase driver predictability.

In Saratoga Springs, a median was added to, among other things, ensure that drivers in the left turn lane turned left. Note that the median on the far side of the intersection is wider and bollards are placed to protect pedestrians. In Dortmund the "recovery zone" opposite the left

Courtesy New York State DOT

Median – *before*
Saratoga Springs, New York (USA)

Courtesy Reid Ewing

Median – *after*
Saratoga Springs, New York (USA)

turn lane has been filled in with dirt and a new curb. In Veracruz the design of the median allows the driver in the left turn lane to turn left or continue straight. This not only is confusing to pedestrians but other drivers as well.

It is easy to say that drivers should be more predictable, but the same can also be said for pedestrians. How the person on foot interfaces with traffic is also a consideration. No one wants to hit a pedestrian, or be hit by a car.

Transit station areas can be prone to vehicle-pedestrian incidents for several reasons. First, customers have a tendency to run to catch an approaching bus or train without paying close attention to signals (see image below). 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) pedestrian 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 rushing transit customers and inattentive drivers can produce lethal consequences.

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 of 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

Michael King

Left turn lane with recovery zone
Veracruz, Mexico

Michael King

"Recovery zone" eliminated
Dortmund, Germany

Lloyd Wright

Customers rushing to catch their bus can be put at risk from unsafe crossings
Quito, Ecuador

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 on the island, which makes it nearly impossible to predict what is going to happen. The one on the right is shown with the proper amount of lighting.

Michael King

Pedestrian refuge island – without lighting
Guangzhou, China

Michael King

Pedestrian refuge island – with lighting
Guangzhou, China

Vehicular Volume

As stated above, a street with fewer cars will be generally safer for pedestrians (unless those few cars travel at excessive speeds). By utilizing the physical space previously allocated to other vehicles, a BRT alignment can reduce the capacity and therefore the volume of traffic. Other techniques include auto-restricted streets, off-street pathways, bicycle boulevards and pedestrian-oriented corridors which extend the reach of the BRT system.

The development of dedicated pedestrian zones around a BRT station can be mutually beneficial for pedestrians and public transport systems. The BRT system helps alleviate the necessity of costly car-based infrastructure in the city core. The dedicated pedestrian zones provide a concentration of customers that can feed directly into the BRT system. Curitiba is a leading example of integrating dedicated pedestrian zones with a BRT system.

Lloyd Wright

Pedestrian promenade
Curitiba, Brazil

Michael King

Street converted to cycling and walking only
Morogoro, Tanzania

Crash History

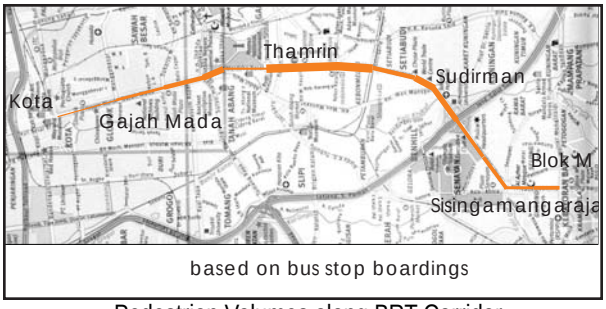
Determining where pedestrians and other vulnerable road users are hit by vehicles is a fundamental step in the safety analysis for planning a transit station. Simply put, locations with high accident rates are not safe for a transit station, unless mitigation measures (as described above) can be installed to improve conditions. Mapping traffic accident locations is the key to this analysis.

Planners should first collect traffic accident (crash) data for incidents involving non-motorized road users from the police and map the locations as precisely as possible. A division between intersection and non-intersection accidents is required. Even though the numbers are likely to be significantly underreported, this simple mapping exercise should make it possible to identify particularly dangerous locations.

In the example below, pedestrian volumes along the BRT corridor in Jakarta were compared to injury locations. This comparison was used to demonstrate that higher pedestrian volumes are not necessarily accompanied by more deaths and severe injuries. In fact, it has been shown that vehicle speed is a better indicator of injury severity. Pedestrian volumes usually mean more absolute numbers getting hit, but generally with less severe outcomes. This is the 'Safety in Numbers' argument that is gaining currency within pedestrian safety circles.

In any type of statistical analysis one should always be aware of the difference between absolute and proportional numbers. For example, the number of children hit by cars may have fallen from one year to the next, but if fewer children are walking, then it may be proportionally more dangerous. This type of analysis is most useful for traffic calming, where the incidents of property damage may increase, but the rate of hospitalization and deaths decreases.

Jakarta BRT
Pedestrian Volumes



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Pedestrian Volumes along BRT Corridor
Jakarta, Indonesia

Jakarta BRT
Pedestrians Hit by Vehicles

ITDP

Pedestrian Injuries and Deaths along BRT Corridor
Jakarta, Indonesia

The chart at right lists factors which can be used to determine the relative safety of a location or area. It includes direct (property damage, emergency medical services (EMS), medical treatment, lost productivity, insurance payouts) and indirect (insurance premiums, automobile safety features) costs. These multipliers can be applied to existing crash data to show the approximate annual cost of the existing roadway configuration. It can also be used to estimate potential cost savings of a proposal relative to the cost of construction.

Factor	Severity
1300	Fatality
90	Incapacitating Injury
18	Evident Injury
10	Possible Injury
1	Property Damage Only

Crash Cost Factors in the USA
Source: Homberger, et al. Fundamentals of Traffic Engineering, 14th Edition. Institute of Transportation Studies, 1996.

Design Standards And The Law

The notion of design standards is well established in the construction industry. Buildings and bridges are constructed with a 'design load' based on expected use. Industry standards are used to normalize an industry and make it more efficient - light fixtures come in 'standard' sizes, so that we can be sure the bulbs will fit. Standards are also codified to advance a particular concern, like making all toilets accessible to those who use wheelchairs.

As design standards are brought into the public realm, especially with regard to streets and highways, there is the risk that the standards will not conform to the law. With light bulbs, if a manufacturer makes the wrong size, people simply will not buy it. If a road is designed to restrict an 'unsafe' activity, but that activity is legal under the prevailing statute, then there is a conflict. To exemplify, there is the story of Zebra and Pelican crossings in the United Kingdom.

In the past few decades, British traffic authorities have been converting unsignalized, midblock crossings into signal-controlled crossings under the theory that more control would increase safety.* However, the law regulating walking behavior was not updated to require pedestrians to obey the new signals. They could, and did, cross regardless of the signal. Recent research has shown that Pelicans do not increase safety, and in some instances are more dangerous than a standard Zebra. This brings up the question of who is acting with impunity: the pedestrians or the traffic authorities?

Another example of this conflict is found in New York City where it is permissible to cross the street between two intersections (midblock), but not if both adjacent intersections have traffic signals. If one of the intersections has a signal and one has a stop sign, then pedestrians may cross midblock. It can be said that relatively few people know of this statute, and if they did, would probably not obey it. Similarly, the traffic authorities refuse to sanction midblock crossings, believing them to be unsafe (albeit legal).

The point is that design standards should reinforce existing laws, and vice versa. In designing a road, one implicitly dictates lawful actions, from vehicle speed to crossing locations. This does not give the designer the license to curtail legal behavior, or encourage unlawful ones.

While guidelines are useful to focus the planning process, it is important to keep in mind that design guidelines are just that, guides. They are not a substitute for engaging in the design process. Guides are also historically conservative, in that they seek to codify established practice. Furthermore, that codification may take years or decades. Be especially wary of guidebooks that have been copied verbatim from other sources, which quite possibly rely on out-of-date research. It is best to look at guidebooks as nothing more than reference manuals.

* http://www.driveandstayalive.com/articles%20and%20topics/pedestrians/pedestrian-crossings-and-crosswalks.htm.

Leading Pedestrian Interval

A novel technique gaining favor with pedestrian safety experts 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.

Analysis of 10 years of crash data from New York City (USA) shows that intersections with LPIs have 26 percent fewer pedestrian injuries and those injuries are 36 percent less severe.* Data from San Francisco (USA) show that 89 to 98 percent more drivers yielded to pedestrians after LPIs were installed.† Data from St. Petersburg, Florida (USA) show that 95 percent more drivers yielded to pedestrians after LPIs were installed.‡

The image at top right shows the pedestrian phase of an LPI . The image below right shows the vehicle phase. Note that the pedestrians have cleared the intersection.

Michael King

Walk phase of an LPI
New York City, New York (USA)

Michael King

Walk plus vehicle phase of an LPI
New York City, New York (USA)

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* Independent research by Michael King

† "Pedestrian Head Start Signal Timing" by J. Fleck, in Compendium of Papers. Institute of Transportation Engineers, District 6 Annual Meeting, San Diego, California, 2000.

‡ "Field Evaluation of a Leading Pedestrian Interval Signal Phase at Three Urban Intersections" by R. Van Houten et al., in IIHS Status Report, Vol. 32, No. 7, Aug. 30, 1997.

The time-lapse sequence below shows a Leading Pedestrian Interval in action. The pedestrian signal is on in frames 1 and 2. In frame 3 it is joined by the green light for vehicles. The first right-turning vehicle does not enter the crosswalk until frame 8. The first left-turning vehicle enters the crosswalk at frame 12. By this time most pedestrians have crossed.

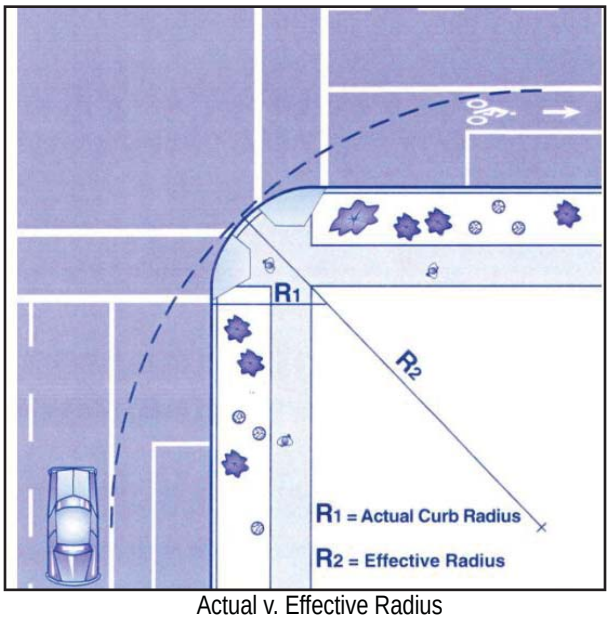
Michael King

Time-lapse of Leading Pedestrian Interval
New York City, New York (USA)

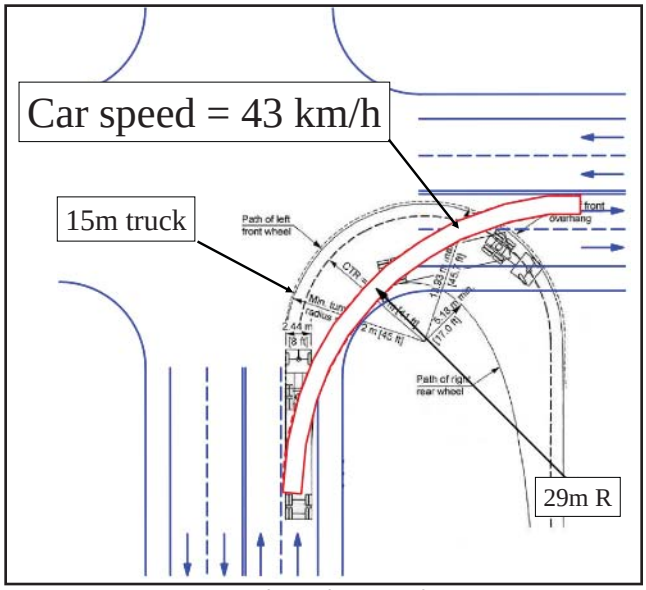
Effective Turning Radii

It is common for roadway designers to use corner radii as a proxy for turning radii. The problem with this practice is that the two may not be equal, and often the turning radius is larger. It is better to use the 'effective turning radius – the widest possible turn that a driver can make. The image on the left below demonstrates the difference between the two.

In the image on the right, the intersection has been designed for a 15m long truck to turn the corner from the inside lane. The actual curb radius is 9m, but the effective turning radius is 29m. This layout allows a typical car to round the corner at 43 km/h, a speed quite unsafe for pedestrians in the crosswalk.



Actual v. Effective Radius



Car v. Truck Turning Speeds
Source: AASHTO Green Book, 2001.

Limits Of Crash Statistics

Vehicle-vehicle incidents and incidents involving fatalities are typically reported with reasonable accuracy and need not be adjusted. However, research indicates that only 35 to 85 percent of vehicle-bicycle and vehicle-pedestrian incidents involving injury are included in typical crash statistics. A study of California children estimated that police reports only cover 80 percent of hospital admissions.* A British study found that only 67 percent of slight injuries to pedestrians were reported while 85 percent of serious injuries were.† In Germany the figures are 50 percent for major injuries and 35 percent for minor ones. Based on this research, it is appropriate to adjust vehicle-bicycle and vehicle-pedestrian injury statistics upwards by at least 50 percent.‡

* Agran PF, Castillo DN, Winn DG. "Limitations of Data Compiled from Police Reports on Pediatric Pedestrian and Bicycle Motor Vehicle Events." Accident Analysis and Prevention, Vol. 22, No. 4, 1990, pp. 361-370.

† James, H. "Under-reporting of Road Traffic Accidents." Traffic Engineering and Control, Dec. 1991, pp. 574-583.

‡ Hautzinger H, Dürholt H, Hörnstein E, Tassaux-Becker B. Dunkelziffer bei Unfällen mit Personenschaden (Unreported Proportion of Personal-Injury Accidents). Report M13. Bundesanstalt für Strassenwesen (Federal Highway Research Institute), Bergisch Gladbach, Germany, 1993.

Conflict Analysis

Researchers at Lund University in Sweden have developed a 'conflict-analysis' technique where a location is observed and conflicts between various roadway users are observed and recorded. These 'conflicts' could be near misses, evasive maneuvers or simply a reduction in speed. The idea is that this type of information paints a more complete picture of the safety at a particular location than do accident statistics. The technique is especially useful in contexts where most traffic incidents go unreported.

When Crosswalks Need Help

Recent research suggests that Zebra crosswalks should only be used by themselves on low-volume, narrow, or low-speed roads. At higher volumes, speeds, or number of lanes, Zebra crosswalks in and of themselves do not make crossings safer, and more substantial treatments such as traffic calming, refuge islands or increased lighting are required.

Type of Road	Speed limit *km/h*	Daily volume < 9000	9000-12000	12000-15000	> 15000
2 lanes	< 50	X	X	X	X
	50-60	X	X	X	=
	> 60	=	=	0	0
3 lanes	< 50	X	X	=	=
	50-60	X	=	=	0
	> 60	=	=	0	0
4+ lanes w/median	< 50	X	X	=	0
	50-60	X	=	=	0
	> 60	=	0	0	0
4+ lanes, no median	< 50	X	=	0	0
	50-60	=	=	0	0
	> 60	0	0	0	0

Comparative Safety of Zebra Crosswalks in the USA*

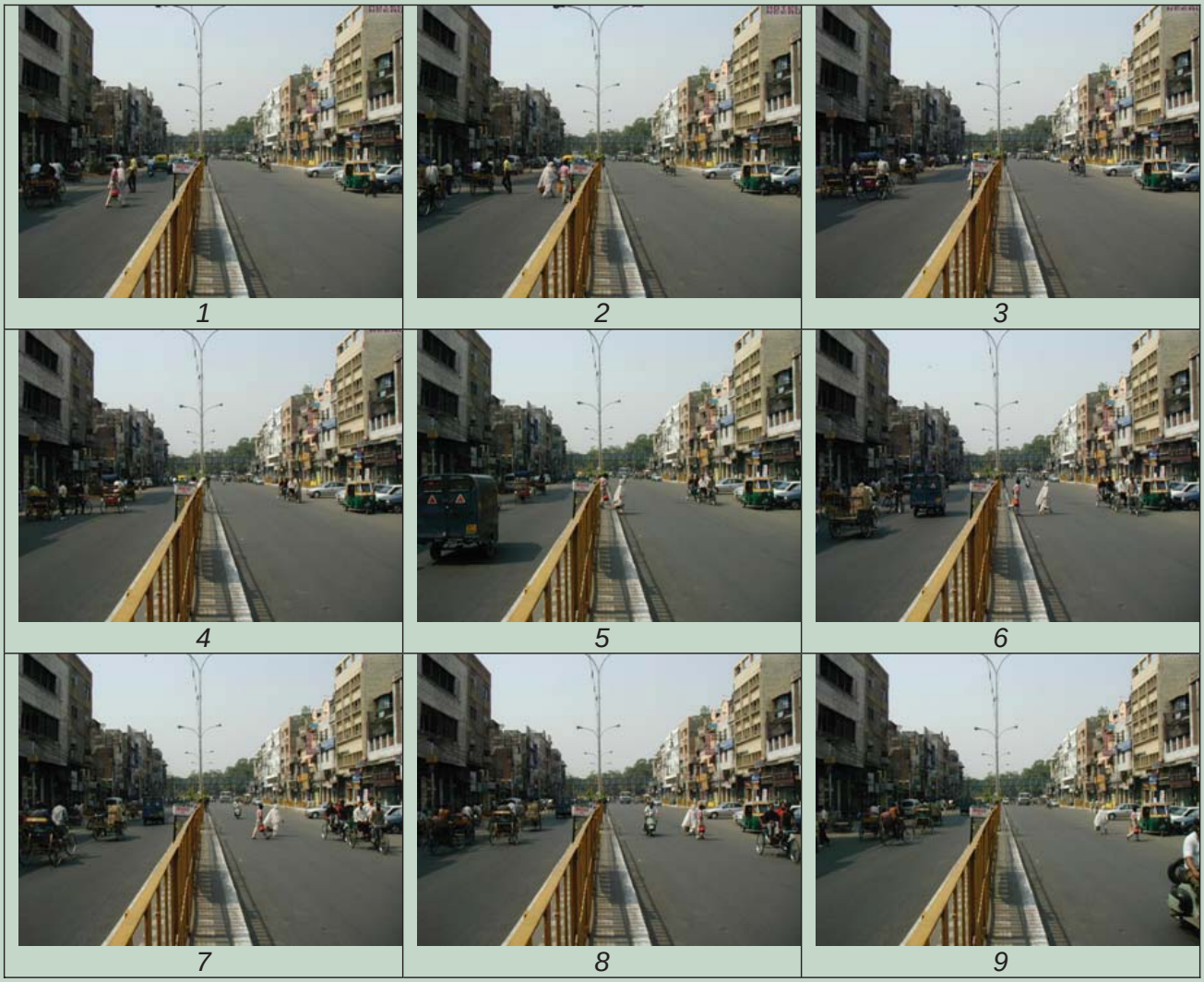
KEY:
- X — Zebra crosswalk alone increases pedestrian safety
- = — No difference in pedestrian safety with or without Zebra crosswalk
- 0 — Zebra crosswalk decreases pedestrian safety, need other treatments

* Zegeer, C. et al., "Safety Analysis of Marked Versus Unmarked Crosswalks in 30 Cities," ITE Journal, January 2004.

Documenting Pedestrian Behavior

Time-lapse photography is a very informative methodology to document how people, whether drivers, walkers or cyclists, use a street. With the advent of digital cameras, it is becoming increasingly affordable. This technique not only gives planners and designers information with which to design spaces, but also can be used to convince politicians and the public.

The series of images below documents how people use a median to cross a street safely. By using the median as a refuge, the woman in the white sari only has to cross one direction of traffic at a time. This means that she can take advantage of gaps in one traffic stream, then the other.



Michael King

Time-lapse of median used for a safer pedestrian crossing
Delhi, India

Shared Space

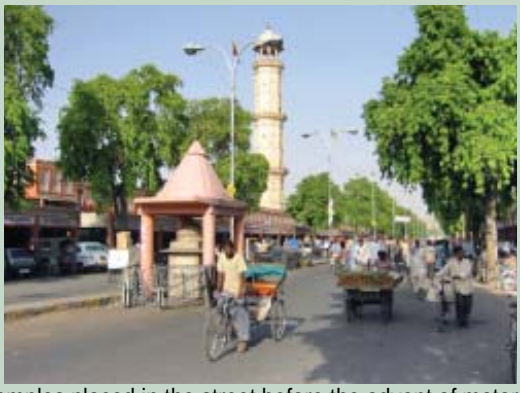
One of the most innovative concepts in recent years has been the idea of "shared space", also known by several other names including "post-traffic calming", "second-generation traffic calming", "psychological traffic calming", and even "naked streets". In some respects "shared space" represents the antithesis to traffic calming, and yet, both share the ultimate goals of slower vehicle speeds and reduced accidents. With shared space, all physical differentiation between car space and pedestrian space is removed.

Not surprisingly, Shared Space has its roots in the Netherlands, where woonerfs began in the 1970s. While woonerfs (Home Zones in the UK) are typically found on small residential streets, Shared Space extends to larger commercial thoroughfares. Cities such as Drachten and Oosterwolde in Holland, Copenhagen and Christianfield in Denmark, Wiltshire and Suffolk in the UK, and West Palm Beach and Cambridge in the US now have Shared Space streets. Bicycle-priority streets (Lemgo in Germany, Berkeley in the US) are close cousins. One can also find de facto Shared Space in many cities around the world (see images below).

In 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. A roundabout, for example, can be considered a "first generation traffic calming" technique. It works by replacing a traffic signal with an all-yield condition. In Shared Space the signal and roundabout would be removed altogether. The premise is that lack of assigned priority (as

Courtesy Cara Seiderman

Vehicles are allowed on this "shared street"
Copenhagen, Denmark



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Temples placed in the street before the advent of motor vehicles calm traffic
Jaipur, India

Michael King

Tourist street with traffic
Bangkok, Thailand

Shared Space (continued)

with a signal) actually creates safer conditions by forcing drivers, pedestrians and cyclists to interact, sans rules.

By eliminating specific designations for motorized road users the total amount of usable public space for non-motorized transport increases. Vehicles still use the street, albeit at a slower rate. Moreover, since driver speed is entirely self-enforced, second generation traffic calming can be seen as the ultimate form of context sensitive design. Drivers' speed is determined not by arbitrary speed limits, but rather the presence of pedestrians, cyclists and public furniture in the "roadway".

Advocates of Shared Space claim that traffic controls, even those that make cars go slower, are actually less effective than the total absence of rules. The concept is that 'familiarity breeds complacency'. Because traditional traffic engineering has relied so heavily on street signs, lane stripes, and other tools to signal to the driver where, when and how fast to proceed, drivers can switch into auto-pilot with the attendant slowing of reflexes that this state entails. When cyclists, pedestrians or playing children interfere with such drivers, results can be deadly.

The extent to which Shared Space is applicable to larger cities and to developing cities is not yet known. While the lack of signage results in greater caution from motorists in the Netherlands – and fewer vehicle-pedestrian collisions have resulted there - it is not clear if the same success would be achieved on the streets of Lagos, Jakarta, or São Paulo. Additionally, as traffic volumes increase the lack of signalling may eventually reach a critical point in which gridlock prevails. Nevertheless, Shared Space represents an innovative approach that will likely receive increasing attention.

Michael King

Narrow, low speed, textured street
Beverungen, Germany

Michael King

Pedestrian street with auto access
Limburg, Germany

Michael King

Street with vendors and mixed traffic
Jakarta, Indonesia

ACCESSIBILITY

Accessibility is the ability to reach a BRT station from an external origin, and to travel from the station to the final destination. The dominant BRT planning concerns include overcoming physical barriers (specifically for travelers with disabilities), avoiding excessive volumes which may impede timely access, providing a safe route, and minimizing conflicts and detours.

Physical Conditions

The following are the key measures which should be included in designing a BRT facility, presented according to the nature of a pedestrian's disability.[2]

Limited Mobility (wheelchair)

The Paved Accessible Route (PAR) is the pedestrian accessway prescribed to conform to ADA standards. Design guidelines for a PAR (presented below) are based on the physical requirements needed to offer a consistent and reliable accessway to a person in a wheelchair. The PAR is not just a sidewalk or individual walkway, but the entire system providing accessibility to all destinations. These guidelines have been developed with access to all destinations in mind, but are specifically applicable here for access to and circulation within a BRT station.

Walkways

The PAR should be a minimum of 1.2m wide (though greater width is recommended to provide enough clearance for two wheelchairs to pass each other);

- The surface of the PAR should be stable and firm, and consist of slip resistant material;
- Transitions from ramps to planes should be flush. 'Lippage' – changes in elevation that are vertical – may not exceed one-quarter inch (6.5mm);
- Materials should be smooth to minimize vibration;
- At existing planes with grades of more than 11%, a level strip should be provided to serve as a site-specific leveler;
- Cross slopes should be consistent (i.e. planar) and should not exceed 2%;
- Obstacles, including grates, access covers, poles, parking meters, and bike racks, should be kept out of the PAR;
- Maximum width of cracks along the PAR:
  - 6.5mm if vertical, 13mm if beveled.
  - Openings may not exceed 13mm horizontally.
  - Must be at least 0.75m between two horizontal planes.
  - Over 13mm must be 1:12, like a ramp.

Crossings

- Curbs along the pedestrian route to the transit station should all be ramped to provide access to customers in wheelchairs and to those carrying wheeled objects such as bicycles or trolleys
- Corners should include small curb radii, to maximize visibility of pedestrians to turning drivers;
- The maximum slope of a ramp should be 1:12 and ramp runs should be straight;
- Ramps should be located directly adjacent to crosswalks to avoid the need for turns once a wheelchair is in the street;
- Include a level area at the toe of the ramp to prevent water from pooling.

2 Information on accessible design is taken largely from guidance published by the United States Access Board (www.access-board.gov). This is the agency charged with developing design guidelines for the Americans with Disabilities Act (ADA) of 1990, which established design requirements for the construction or alteration of facilities, including transit facilities.

There is little value in making station platforms and transit vehicles friendly to the physically disabled if it is impossible for those individuals to reach the stations in the first place. The image below shows a good, accessible route to transit.

Courtesy Queensland Transport

Level surfaces can greatly increase the accessibility of transit stations for those with physical disabilities

Michael King

Level transition between sidewalk and crosswalk
Rio de Janeiro, Brazil

Limited Vision (blind)

Visual impairments require different types of safety features along the PAR. These measures are intended to provide a guide along the PAR, which can be followed utilizing senses other than the eyes. The critical locations for these measures are at intersections and borders between pedestrian accessways and vehicular roadways.

The intention at intersection crossings is to provide information to the pedestrian about where the pushbutton is located (so the pedestrian can initiate the Walk phase, and sense when the Walk phase is active). Options include:

- Accessible Pedestrian Signals (APS)
- Pushbutton locator tones to alert the pedestrian to the
- Audible WALK indication
- Vibro-tactile WALK indication
- Tactile arrow
- Tactile map or pushbutton information message
- Automatic sound adjustment

Detectable warnings are raised bulges at key locations which alert the pedestrian to a changing condition – stop signs for the blind. These warnings are appropriate to denote station edges and curbs. Truncated dome detectable warnings are recommended at a depth of 60cm from the base of the curb ramp or level street transition, and along the width of the ramp or level area.

Geometry and landscape modifications at intersections can also improve accessibility. Design recommendations include providing two ramps per corner where possible. Ramps should cross perpendicular to the curb and gutter.

Quality of Pedestrian Experience

A safe environment for pedestrians is an important factor in planning a BRT station, but without viable access the facility may never be used. Accessibility is primarily based on the other demands for space compared to the amount of space available (volume and delay), as well as context and security.

Michael King

Audible signal at crosswalk leading to BRT station
Leon, Mexico

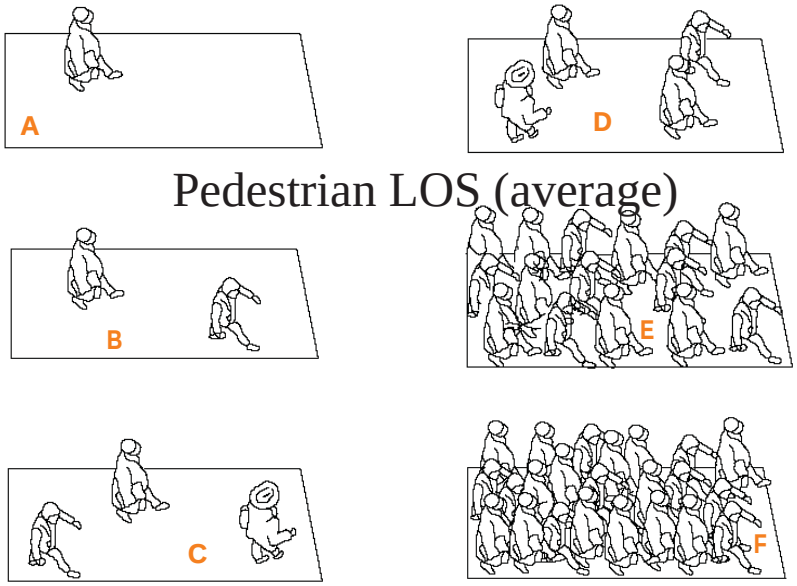
Courtesy Beneficial Designs, Inc.

Vibro-tactile push button from crosswalk signal

Walkway Volume and Width

Walkway level of service (WLOS) is a scaled measurement which quantifies the flow of pedestrians in a given walkway width. It is most applicable to sidewalks, corridors and bridges with high pedestrian volumes where the essential concern is the provision of sufficent space. Calculating WLOS requires two inputs: effective width and number of pedestrians per hour. A pedestrian facility provides a high WLOS if few pedestrians are present.

The charts below show the range of area needed per person under average and platoon conditions. Platoons are created when a group of pedestrians is released en masse by crosswalk signals, Metro doors or other temporal displacements. A platoon of walkers requires more space than if the same number of people were spaced evenly throughout a sidewalk. When two platoons meet each other, as in a crosswalk, the spatial requirements are even greater.



	Average	Platoon
A	> 5.6	> 49.2
B	> 3.7 - 5.6	> 8.4 - 49.2
C	> 2.2 - 3.7	> 3.7 - 8.4
D	> 1.4 - 2.2	> 2.1 - 3.7
E	> 0.7 - 1.4	> 1.0 - 2.1
F	<= 0.7	<= 1.0

square meters per person

Walkway average level of service
Highway Capacity Manual 2000 (Transportation Research Board)

Photography is a powerful tool to document and demonstrate issues in the walking infrastructure. The images at right show the condition of the sidewalk (or lack thereof) between a government office building in Mexico City and the nearest Metro station. It is quite clear that the roadway has been designed for the driver, in spite of the continual presence of walkers.

Michael King

Sidewalk between municipal offices and nearest Metro station
Mexico City, Mexico

Michael King

Sidewalk between municipal offices and nearest Metro station
Mexico City, Mexico

Pedestrian Delay

Time is a key element to determining the best method for accessing a BRT station within an active roadway. Pedestrians will not want to significantly increase their access time, especially when the bus is coming. Instead they will find different (possibly unsafe) routes or not use the facility at all.

Research shows that the likelihood of compliance is significantly reduced if delay is greater than 30 seconds. Applied to the BRT station, an above-grade crossing that has a travel time of 30 seconds or more than the at-grade route will generally not be effectively utilized. In a similar fashion, elevators are generally designed so that people do not have to wait more than 30 seconds.

Pedestrian Delay (seconds)	Likelihood of Noncompliance
< 10	Low
10-20	
21-30	Moderate
31-40	High
41-60	
> 60	Very High

Pedestrians Patterns per Delay
Highway Capacity Manual 2000 (Transportation Research Board)

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.

At-grade crossings should be placed as close to the station entrance as possible. Otherwise, customers may simply cross at an uncontrolled point closer to their intended destination. The image below illustrates a poorly placed crossing, which is located some 100 meters away from the station. Passengers must walk 100 metres down the roadway and then 100 metres back to access a point that is actually less than 12 metres from their starting point.

Michael King

Crosswalk 100m away from BRT station
Leon, Mexico

Context

Beyond the technical assessments described above, planning a BRT station requires an understanding of how it fits within the urban context. Key factors which influence the viability of a station include flow, conflicting movements, and detours. An additional element of context is the pattern of land uses surrounding a BRT station, to which the traveler may want to access (the goal of the trip). Historically, segregated land uses were favored in order to minimize conflicts. Such land use patterns reduce the opportunities for access, forcing residents to drive to many individual destinations to run errands, attend school or find work. Instead, more mixed land use provides more concentrated origins and destinations, which can be served by a BRT station within walking distance.

Context should also include acknowledgment that many of these factors may be perceived and not actual. Even if a factor is only perceived, the resulting impact will limit the effectiveness of the BRT station.

The documentation of context will be necessarily qualitative. For example, if riders can see the BRT station across a plaza or large street, they will want to find the shortest route there. However, if the paths are organized such that the station is not visible until it is directly accessible, then they will be less likely to take a detour. Alternatively, placing the station in a prominent, more visible location will increase its presence, security and use. Ultimately one needs to have a good understanding of human travel characteristics when discussing pedestrian routes to a BRT station.[3]

Security[4]

Whether based on empirical crime data or public perception, if potential riders feel unsafe walking to a BRT station that can be enough to nullify the system's effective use. Coordination with local police departments and community organizations may be the only way to accurately determine the importance of this factor. If a location or route is actually unsafe, as verified by incident statistics, alternatives may be required. On the other hand, implementation of security elements, ranging from lighting to monitoring to providing security personnel, may be the only way to overcome perceptions of crime.

While security and police techniques are a subject unto themselves, there is much to be said for "eyes on the street" and "safety in numbers". The more people in a particular area, the safer it will be due to the number of potential witnesses to any crime. These witnesses can be other people walking, police officers on the corner, or simply shop- or homeowners looking out from their windows and doors. By improving the physical and safety conditions on a route to transit, more people will walk, which will make them more secure.

3 For more information on human travel characteristics, see Life Between Buildings: Using Public Space. Jan Gehl, Danish Architectural Press, 1971.

4 "Security" usually refers to personal assaults such as muggings and theft. "Safety" usually refers to traffic incidents and walkway conditions.

The above sections discussed the planning and design of safe and accessible BRT stations. On the macro level, stations should be located so that they best serve the general population and maximize ridership potential. While there are many non-pedestrian issues in the location of stations, there are a few particulars which directly relate to pedestrian access and safety. Data collection and mapping is recommended to determine where people are (origin), where they want to go (destination), and where BRT stations can be located to serve them (potential site).

A well-designed pedestrian access plan will provide a natural flow of walking customers from the surrounding area. System planners should ask a few basic questions regarding the quality of pedestrian access. Are the pedestrian walkways leading to the station well maintained? Are they sufficiently broad to comfortably handle the expected pedestrian traffic? Are they safe and well lit? Is there adequate signage to lead individuals easily to the stations? Are there logical pedestrian connections between major origins and destinations such as shops, schools and work places?

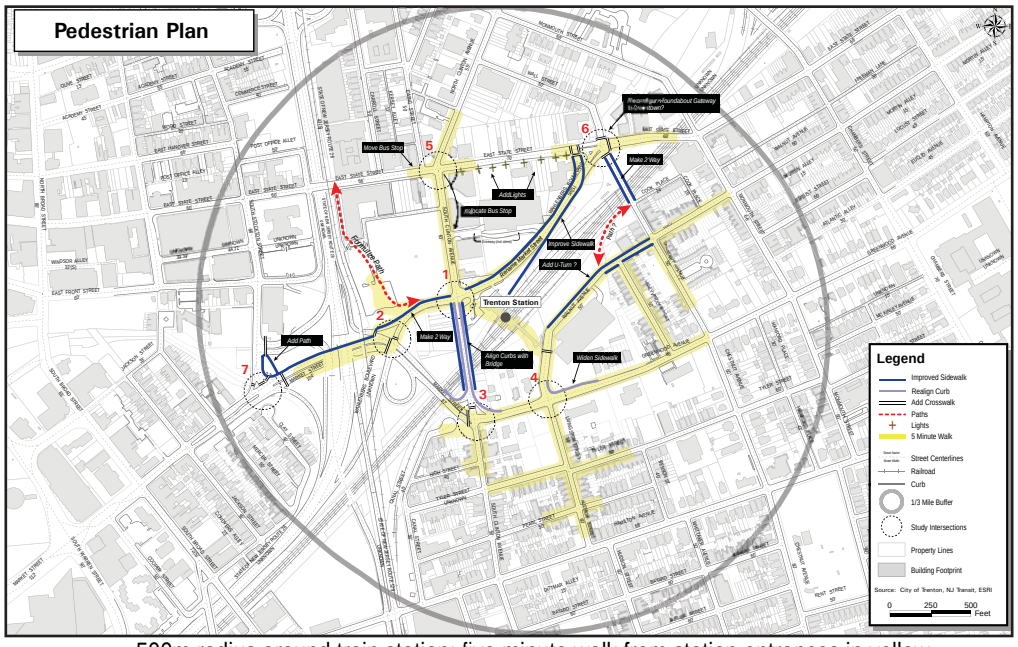
Mapping pedestrian movements in the area of the proposed BRT station provides the baseline data that will help shape the optimum design of the supporting pedestrian infrastructure. Just as traffic counts were an important input element to the BRT modelling process, pedestrian counts and pedestrian movements are important parts of understanding issues around station access.

Service Zones

The project area to be served by a BRT alignment and individual station needs to be divided into 'zones.' A radius of 500 metres is traditionally recommended to determine the catchment area of each station, with zones of roughly 250 square metres delineated. The distance of 500 metres is generally considered the furthest people will walk to catch a bus. If pre-existing origin and destination surveys at a sufficiently small scale exist, the same zones and the same zoning codes should be used.

It is important to record travel distances from the station based on walking travel times. Maps showing areas covered in one, five, ten, twenty, and thirty minute intervals not only indicate the potential catchment area for the station, but may also highlight potential barriers to pedestrian access. For example, a busy roadway near the station may create severance issues for approaching pedestrians. Other impediments such as blocked or non-existent pavements will become evident in a time-based mapping. Also, long signal cycles for pedestrian crossings will increase walking travel times. This type of analysis can often show areas where distances are relatively short but pedestrian travel times are lengthy.

The image on the next page shows a 1/3-mile (roughly 500 metres) circle around the main train station in Trenton, New Jersey (USA). The distance that a person walking at 1.5 metres per second walked in five minutes is shown in yellow. The person followed all traffic laws. This type of analysis is useful in planning station environs. Note that the person was able to walk further where the street network is denser,



500m radius around train station; five minute walk from station entrances in yellow
Trenton, New Jersey (USA)
Nelson\Nygaard

so it would be useful to create passages within blocks. Note also that crossing larger streets took longer, so the person was not able to walk as far. Here it would be useful to minimize delay at signals.

Origin-Destination Analysis

O-D Pairs and Actual Walking Routes

Ideally, a map identifying all significant origin and destination (O-D) pairs for trips under five kilometres should be mapped. It is reasonable to assume that longer-distance trips are rarely going to be made by foot, unless there is a distinct corridor such as a path along a river. Origins and destinations can include markets, schools, houses of worship, parks, residential neighborhoods, shopping centers, office buildings, etc. It is also useful to map major barriers to foot traffic such as expressways, rivers, train tracks and large parcels of land. Conversely one needs to locate the links across these barriers – bridges, tunnels, gates, etc.

Understanding how the origins, destinations, barriers and links relate spatially gives one a good indication of where people can and will walk. This map would be used to:

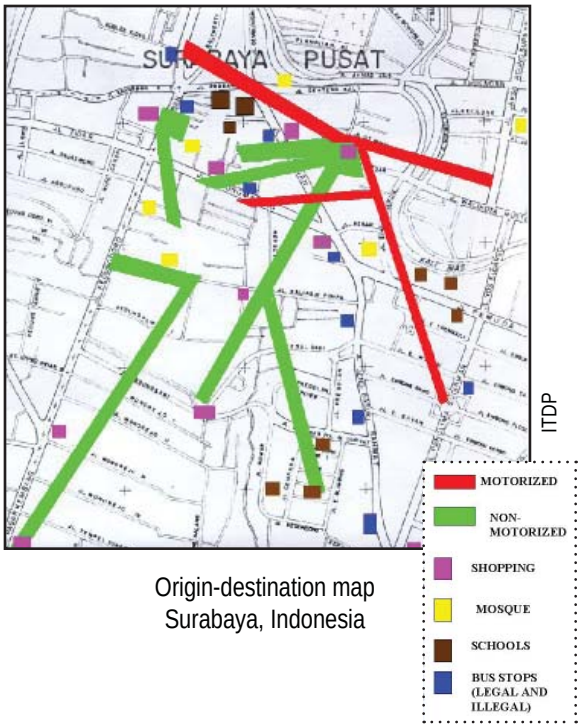
- locate the station,
- show where nominal interventions, e.g. a new bridge over a river, access to the station can be improved, and
- demonstrate where the most significant increases in non-motorized travel could be achieved by providing a new transit service.

Because pedestrian trips are so short and varied, micro-scale detail is often needed to truly understand O-D pairs. It is often useful to map all actual routes between each different major origin and destination pair in the project area. If there is a major trip attractor in the destination zone (e.g. a shopping centre, school or hospital), use this as the destination point. If not, use a central point in each zone. On this map it would be useful to highlight any roads or streets where bicycles or other modes are forbidden (i.e., pedestrian-only streets and other traffic restrictions).

In the first image (below left), motorized access to a station is shown in red and non-motorized routes are shown in green. Bus stops are shown in blue, schools in brown, mosques in yellow and shopping areas in purple. The second image (below right) shows actual routes that students take from their homes to school. Note that some students cross an expressway at a particular point in the bottom right of the image. Note also that no students cross the train line at the top right of the image.

Detour factors

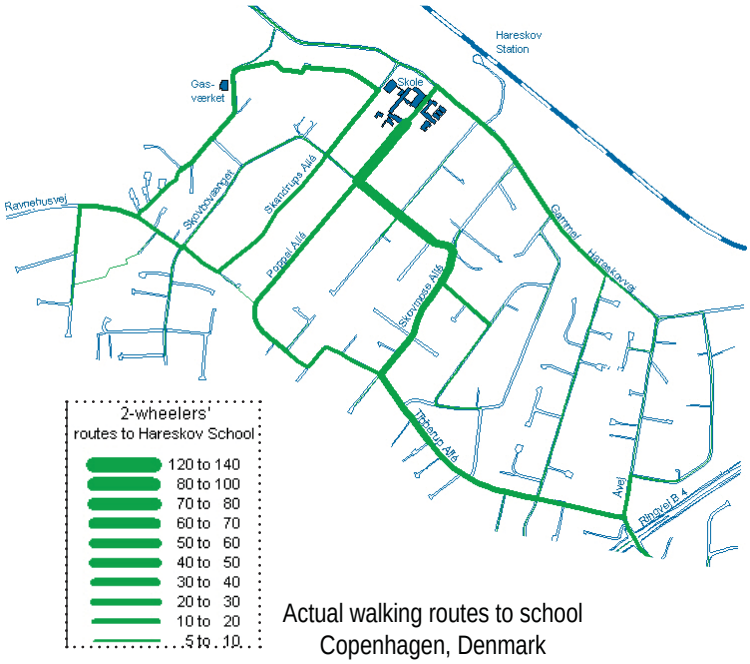
This actual route mapping can be used to calculate detour factors. Detour factors are the most systematic way of identifying major severance problems. Severance problems can be created by unsafe, high-speed roads, by restrictions on non-motorized vehicles on specific streets, by barriers to crossing streets, by a one-way street system, and by large canals, railroad tracks, and other impassable infrastructure.



Origin-destination map
Surabaya, Indonesia

Detour factors are the distance that the average cyclist or cycle rickshaw operator needs to travel out of their way in order to reach their destination, relative to the distance as the crow flies (straight line distance). In a typical European or American traffic grid with no restrictions on non-motorized vehicle travel, the detour factors are generally very low. A detour factor of 1.2, as observed in Delft, Holland, is extremely low. This means that the average cyclist only needs to travel 20% farther than a straight-line distance in order to reach their destination. Mapping of some detour factors in Surabaya indicates that Asian cities with many one-way streets, few intersections, a weak secondary and tertiary street system, and unsafe high-speed roads can have fantastically high detour factors.

Pedestrian connectivity to a BRT station is also a function of the layout of area roads and paths. Street networks which rely on a high number of minor roads which do not connect with each other severely limit the pedestrian's ability to reach the BRT station. This pattern



Actual walking routes to school
Copenhagen, Denmark

reduces the functionality of the BRT station, since it requires longer trips to reach destinations. Conversely, networks developed on an interconnected grid system provide greater accessibility because streets are more connected, which allows pedestrians to travel directly to BRT stations. A grid street system also tends to be more resilient, because the system will not fail if one link is blocked.

Transfers to Other Modes

Locating BRT stations and alignments at key locations offers connections between origins and destinations. This may achieve the primary goal of providing local connectivity to significant trip generators, but there is more to the story. To maximize the effectiveness of any transit mode, it is imperative to offer system connectivity. The same O-D data collected and analyzed as described above can help determine the ultimate destination for potential riders.

Whether other modes (or BRT alignments) exist prior to the planning of the new facility, new BRT stations should provide convenient transfers. Evaluation of rush hour volumes may be the key to maximizing pedestrian convenience at transfer points. Whether alignments run east/west, north/south or any combination, most locations will have dominant flows. Connecting services will be rendered most useful by planning for the overall flow patterns.

Once locations for transfer points are determined, the elements discussed above for safety and access remain constant. Critical safety factors (e.g., reducing pedestrian crossing time and distance) and accessibility criteria (e.g., offering routes which have available sidewalk space) are equally important to providing effective modal connectivity as origin/destination connectivity.

Tracking Surveys

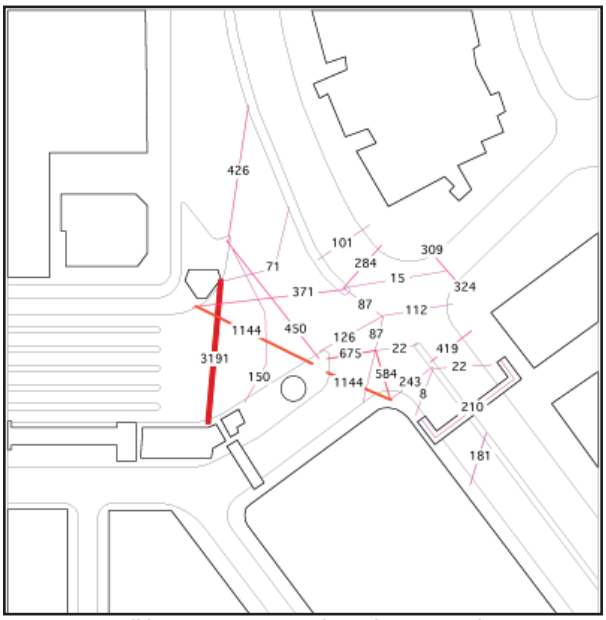
On the micro scale, pedestrian tracking surveys are a useful way to document exactly how people use a street, intersection, or plaza. These surveys have been used to redesign intersections, show how the space is used throughout the day, and demonstrate a specific pattern (such as a need for a crosswalk).

The basic technique for tracking pedestrians is to position surveyors at the 'entries' of the location. [At a typical 4-leg intersection, there are eight sidewalks that lead to the intersection, hence eight points.] As people walk past, the surveyors record on a plan of the area exactly where they walked, where they crossed the street, where they turned around, etc. The surveyors do not actually follow anyone. The survey can last from 30 minutes to two hours, depending on how long it takes to establish the walking patterns. The surveys are then compiled into one composite map and distilled as necessary [see Jakarta images on the opposite page].

The images on the opposite page [Mulry Square] show how a tracking survey can be used to redesign an area. In the lower left is the previous condition. In the upper left is the tracking survey. The upper right has temporary curb extensions (in paint). Note that they accommodate the primary walking movements along. The lower right shows the built condition. In the image on the right [Tubman Triangle] show how curb extensions and refuge islands can be located to mirror walkers.

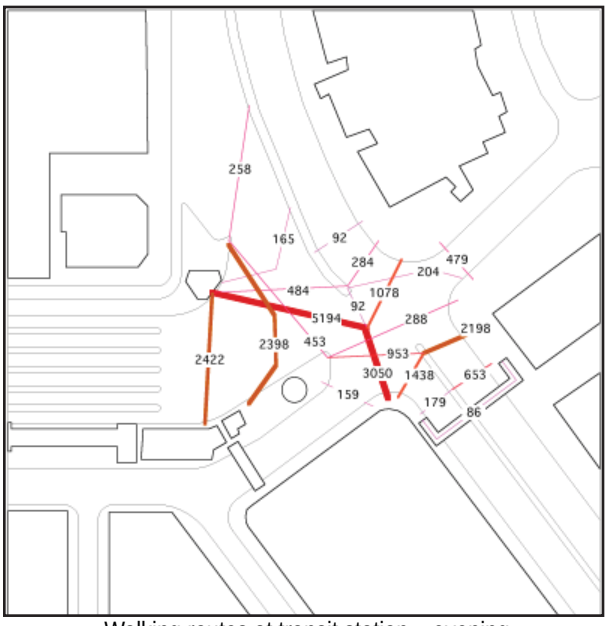
While it is possible to predict walking patterns, humans are highly adaptable. After the station is opened it is good to re-analyze the area and see if the design works. The second two images show the variations between morning and evening use of a transit station. The morning flows are reversed in the evening. It is important to accommodate these differences.

Jakarta



ITDP

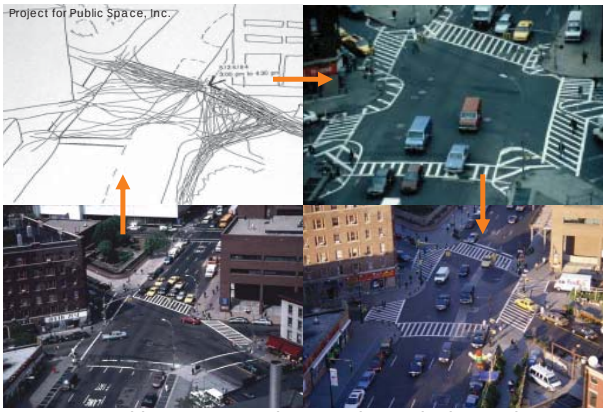
Walking routes at transit station – morning
Jakarta, Indonesia



ITDP

Walking routes at transit station – evening
Jakarta, Indonesia

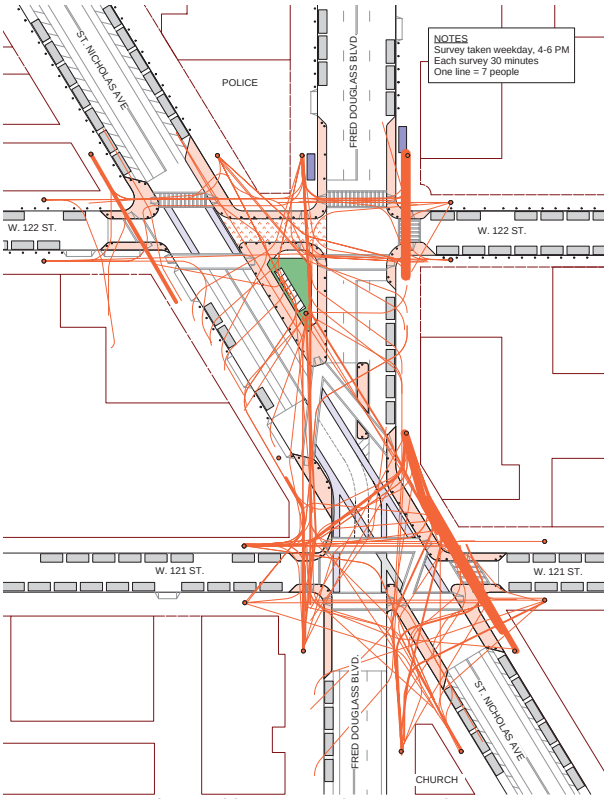
Mulry Square



Courtesy Project for Public Spaces

Tracking survey as intersection redesign tool
Mulry Square
New York City, New York (USA)

Tubman Triangle



Michael King

Composite tracking survey from 19 points
Tubman Triangle
New York City, New York (USA)

Aerial Photos Showing Walking Routes

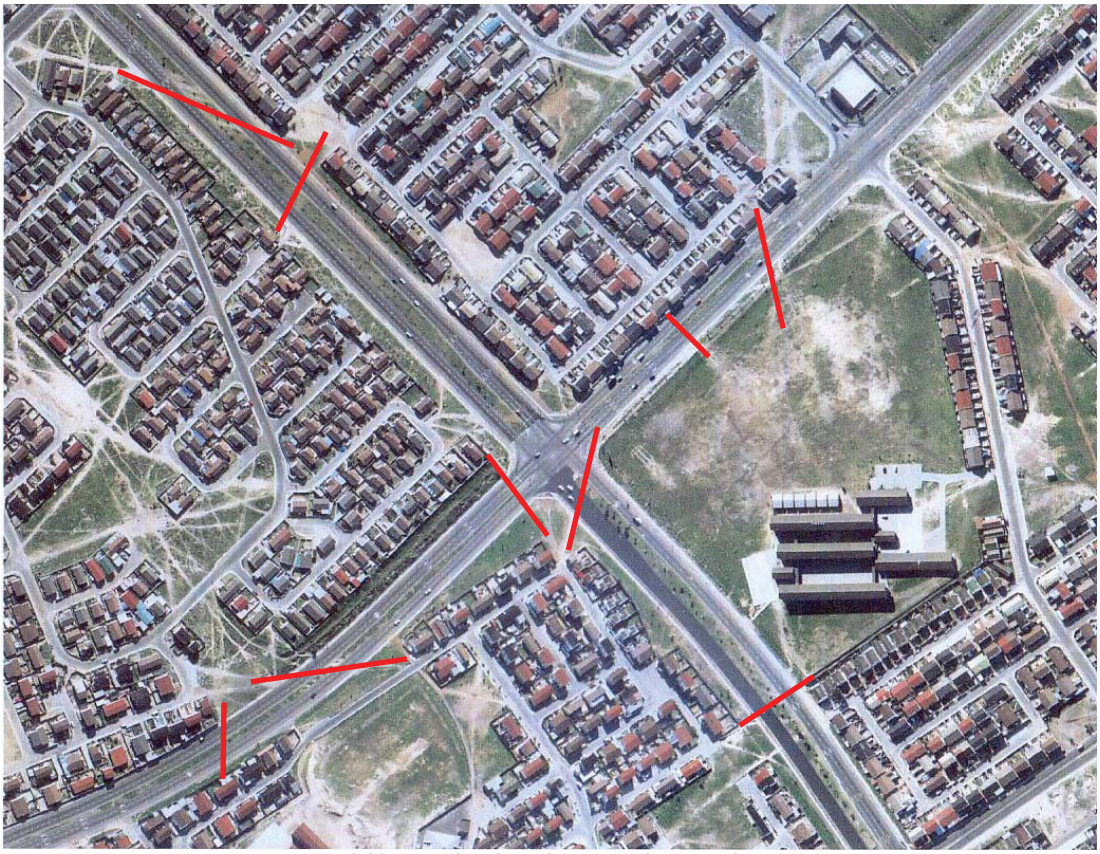
Tracking surveys are highly specific and require a certain amount of personnel to perform. Aerial photographs are a less exact method of obtaining similar information. This is more useful on a macro scale when trying to determine where pedestrian activity is concentrated. Aerial images can show actual pedestrians, say at a market or along a sidewalk, or the paths in unpaved ground.

Michael King

Aerial image showing where people cross the street
Brasilia, Brazil

Michael King

Aerial image showing where people cross the street
Kuala Lumpur, Malaysia



ITDP

Aerial image showing where people cross the street
Cape Town, South Africa

Pedestrian Corridors

The planning of station access extends beyond the immediate transit corridor and into the origin communities themselves. While it is accepted wisdom that transit customers will only walk 500m, in the developing world where alternatives may be sparse or costly people will walk considerably further. This is especially true for major origins and destinations. As such, it may be worthwhile to invest in a few quality pedestrian corridors.

Some of the design factors to consider within these corridors include:

- Quality of pavement materials
- Aesthetic value of walking environment
- Amount of trees, vegetation, verandas, etc. providing climate protection
- Quality of street lighting
- Pedestrian priority at intersections
- Absence of major barriers / severance issues

Some cities now are providing low-cost, covered pedestrian walkways in order to eliminate the disincentive that the weather can bring to walking and cycling. In cities with extreme heat, covered walkways can reduce temperatures by 5-8 degrees Centigrade, and thus make the difference to the viability of comfortably reaching a BRT station.

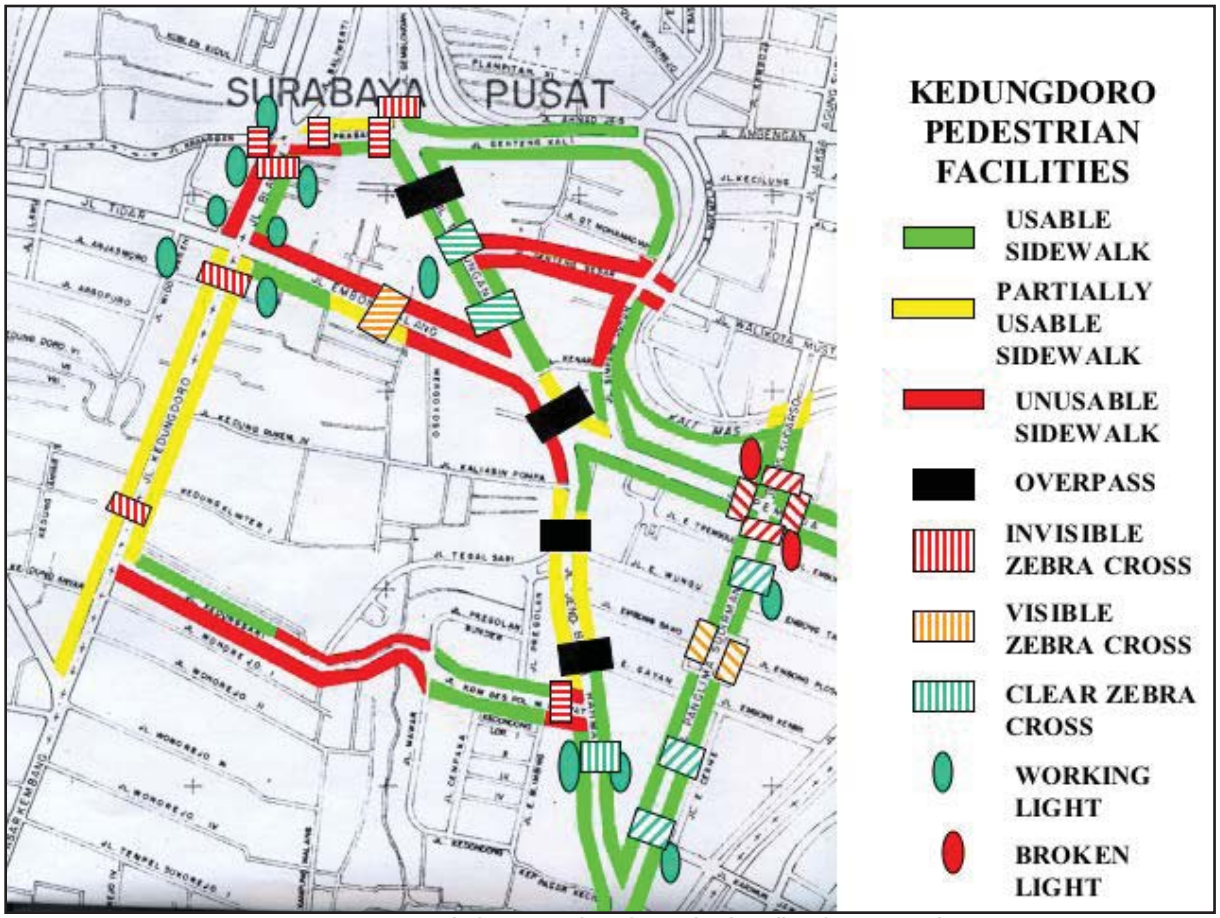
Addressing these details is a relatively small investment in comparison to the total investment for the BRT system. However, providing a safe, attractive, and convenient pedestrian environment can deliver significant benefits in terms of customer satisfaction and total ridership.

Lloyd Wright

Covered pedestrian walkway helps to dramatically reduce pavement temperature and thus encourage walking
Panama City, Panama

APPENDIX A: DOCUMENTING SIDEWALK CONDITIONS

Roadway departments regularly document the condition of pavement, curbs and other roadway features for maintenance and quality control purposes. The same methodology can be applied to sidewalks and other NMT routes. All one needs is a good map, a camera and a measuring wheel. In the following image from Surabaya, Indonesia sidewalks and crosswalks have been rated usable (green), partially usable (yellow) and unusable (red).



GTZ & ITDP

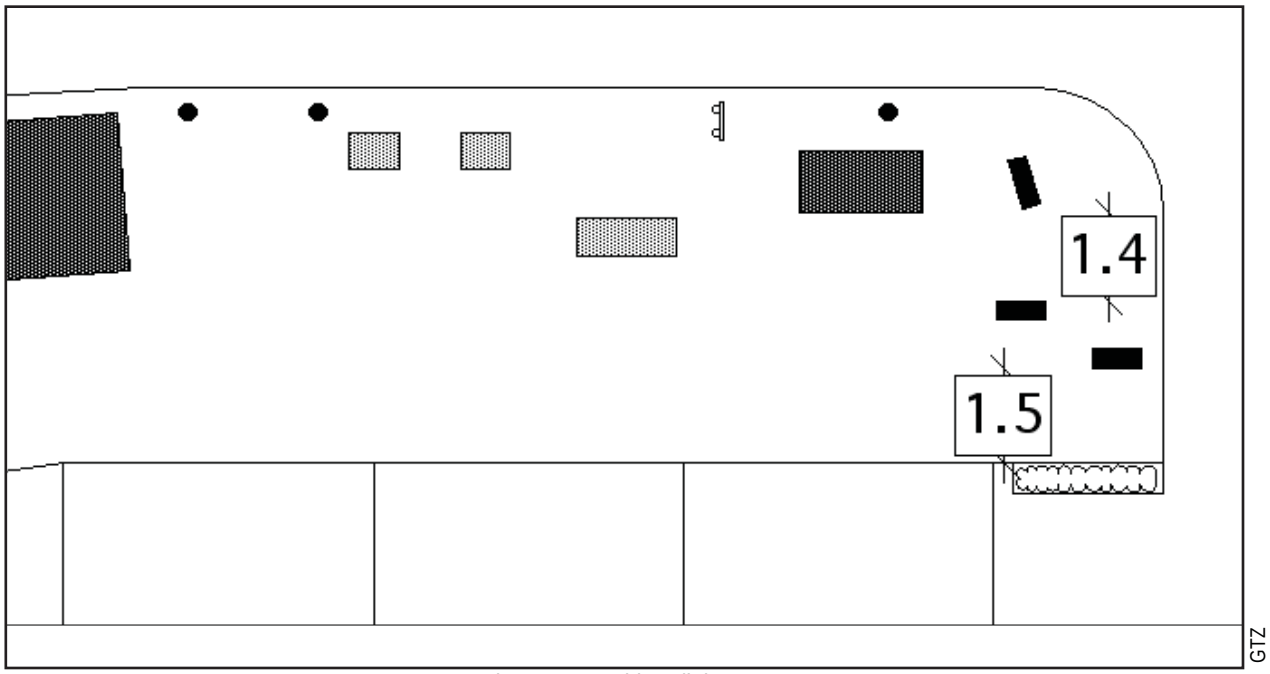
Example for a mapping of perceived quality of NMV travel
Surabaya, Indonesia

To obtain this information one walks the route and photographs at periodic intervals – say every 30m or as the conditions change. The series of images below were taken between a large hotel and a proposed BRT station. This is the route walked everyday by much of the hotel staff, as shown in frame 3. The varying conditions are clearly apparent, from well groomed sidewalks (frame 4) and good wheelchair ramps (frame 6) to trees blocking the path (frame 9) and poles blocking the crosswalk (frame 11).

Michael King

Photographic walking audit
Cape Town, South Africa

Taking the exercise a step further, one measures the sidewalk and notes each obstruction and the remaining width. The plan below shows a sidewalk in Bangkok, Thailand. The sidewalk itself is about 5m wide, but the many obstructions (signs, utility boxes, bus stands, telephone booths, stairways, poles) reduce the 'effective' width, in this case to 1.4m and 1.5m.



Siam Square sidewalk layout
Bangkok, Thailand

Effective width is very important for sidewalk usability. In the two images below, the sidewalk on the left has a clear path in which to walk down the center of the walkway. The sidewalk on the right has its width compromised by trees and steps. There is only about 0.5m clear in which to walk.

For sidewalks in the Siam Square area in Bangkok, Thailand, the Bangkok Metropolitan Authority surveyed the number of pedestrians per hour, and the sidewalks on which they walked. The three charts at the bottom of the page show the results. The first shows absolute numbers for three sidewalk segments. In the second the LOS is calculated for the average and platoon conditions. Both weekday and weekend pedestrian counts were used, much like different peak hours are used in calculating vehicle LOS. Lastly the possible LOS was calculated should all the obstructions (poles, stairways, phone booths, taxi stands, signs) be removed. This was done to demonstrate that by simply removing or reorganizing the street furniture, one can create a clear path, greater 'effective' width and a higher LOS.

There are a number of walking audits and similar products available on the internet. We suggest the following:

http://www.bikewalk.org/vision/community_assessment.htm

http://www.walkinginfo.org/walkingchecklist.htm

http://www.falls-chutes.com...../guide/english/resources/pdf/WalkChecklistJuly-29ForWeb.pdf

Michael King

Driveway slope does not affect effective width
Rio de Janeiro, Brazil

Michael King

Stairs in walkway limit effective width
Brasilia, Brazil

Sidewalk LOS Measurements

	W	W^e		Pk Vol
Phaya Thai & Soi Chula 64	3.8m	0.4m	weekday	1299
			weekend	3360
Rama I & Soi 3	5.9m	1.1m	weekday	1647
			weekend	4692
Rama I & Soi 6	8.2m	1.3m	weekday	345
			weekend	918

Effective Width

Siam Square Sidewalk LOS

		Average	Platoon
Phaya Thai & Soi Chula 64	weekday	D	F
	weekend	F	F
Rama I & Soi 3	weekday	C	D
	weekend	E	F
Rama I & Soi 6	weekday	A	A
	weekend	A	C

Current LOS

LOS w/ no obstructions

		Average	Platoon
Phaya Thai & Soi Chula 64	weekday	A	B
	weekend	B	D
Rama I & Soi 3	weekday	A	B
	weekend	A	C
Rama I & Soi 6	weekday	A	A
	weekend	A	B

Possible LOS

GTZ

Bangkok (Thailand)

APPENDIX B: KANSAS CITY PEDESTRIAN LEVEL OF SERVICE MODEL

Kansas City (USA) has developed a pedestrian LOS model based on five specific measures: directness, continuity, street crossings, visual interest and amenity, and security. The five measures essentially ask five questions:

1. Does the pedestrian network provide the shortest possible route to the transit facility?
2. Is the pedestrian network free from gaps and barriers?
3. Can the pedestrian safely cross streets?
4. Is the environment attractive and comfortable, offering protection from harsh conditions?
5. Is the environment secure, well lit with good line of sight to see the pedestrian, and far away enough from vehicular traffic to provide a feeling of safety?

While Kansas City developed these measures for citywide use, the points below are tailored for use in station access planning.

- **Directness:** The measure of directness is simply how well key destinations (e.g. schools, parks, commercial centers, or activity areas) are connected to the transit facility via the pedestrian network. The directness LOS is based on a ratio of the actual distance and minimum distance between two points. To determine the Directness Ratio, measure the actual distance between a representative key destination and the transit facility and divide it by the minimum distance between those two points.
  - The minimum distance is defined by the grid street pattern using standard sized city blocks (no greater than 660 feet in length), measuring from a representative trip origin to destination by a north-south measurement plus an east-west measurement. An actual/minimum (A/M) ratio of between 1.0 and 1.2 would be considered an LOS A, whereas an A/M ratio of 2.0+ would be considered a failure. An A/M ratio of below 1.0 could be achieved with the availability of a diagonal street.
- **Continuity:** Continuity is the measurement of the completeness of the sidewalk system with avoidance of gaps and barriers. The measure considers not only the presence of Americans with Disabilities Act (ADA) accessible sidewalks for the same routes used to evaluate directness, but also the condition of the pedestrian pathways and whether there are barriers in the pathway (i.e. light poles in sidewalk, newspaper vending machines, etc.). This measure requires a field survey of the most logical routes to the transit facility from key destinations.
  - In the highest level of service, LOS A, the public pedestrian sidewalk not only provides access from key origins, but also connects to continuous sidewalks within those major trip generators (parks, for example). LOS B and C have continuous sidewalks but without direct interior site connections and as the level falls, with increasing maintenance problems and non-standard widths or configurations. LOS F, the lowest level of service, is a complete breakdown in the pedestrian flow, where each pedestrian selects a different route because no pedestrian network exists.
- **Street Crossings:** The Pedestrian Level of Service measurement predicts how easy and safe it will be for a pedestrian to cross streets with various street crossing and intersection designs to reach a transit facility. The Pedestrian LOS is dependent on the type of crossing, the number of lanes to cross, lane widths, travel speed and the presence or absence of parking lanes. For each type of street crossing, the table prescribes a minimum number of lanes for the highest levels of service. As design elements and features are reduced, parking lanes exist, higher speeds are estimated, and/or additional lanes to cross are increased, the LOS is reduced. If parking lanes do not exist and the pedestrian does not need to be exposed to additional travel time, or if traffic speeds are lower than what is typical for the roadway type, or if the traffic lanes are narrower, resulting in less exposure time for the pedestrian, the LOS is increased.

- **Street Crossing Types:** There are four types of street crossings under the Street Crossing Level-of-Service Measure. Each has its own inherent issues and needs.
  - *Signalized Intersections*: Signalized intersections pose major pedestrian crossing problems due to high traffic volumes, turning vehicles, vehicles that stop in the crosswalk, a significant number of lanes to cross, signal indication that is difficult to read or understand, lack of visual connection with the automobile, lack of vehicle driver respect, lack of raised median protection, no corner ramps, and no or inconvenient pedestrian buttons.
  - *Unsignalized Intersection Crossing the Major Street*: Problems are similar to signalized intersections with even greater concern for the number of lanes to cross since pedestrians do not have the protection of the signal. Problems may also include speed of vehicles and lack of adequately marked crosswalks with good lighting, raised median, visibility, and corner ramps.
  - *Unsignalized Intersection Crossing the Minor Street*: The problem at these locations is the vehicle traveling along the arterial turning right or left onto the minor street, while being urged along by a following vehicle.
  - *Mid-Block Crossing*: Problems are similar to the unsignalized major street crossing, including number of lanes to cross and lack of crosswalk presence, lighting, raised median, and corner ramps.
- **Key Street Crossing Elements:** The following are questions about key street-crossing elements to determine its LOS:
  - *How many lanes must the pedestrian cross to reach the transit facility?*
  - *Are travel lane widths 3.5m or less?*
  - *Are on-street parking lanes present parking that would increase the walk time necessary to cross the street?* Are parking lanes are protected by curb neckings or bump-outs
  - *Does the street that needs to be crossed have unusually high travel speeds?* Factors that might affect speed would include minimum cross street traffic, low number of access points, and geometric design.
  - *Are there crosswalks, and are they well marked?*
  - *Are the signal heads easily visible to the pedestrian and the motorist?*
  - *Is the intersection and crosswalk well lit so that the pedestrian is visible (to motorists) at night?*
  - *What are the walk-times (if any) for each phase?* Some signals have the walk-time automatically set for each phase. This is desirable for all pedestrian areas, as it states the importance of the pedestrian. An alternative is the pedestrian button, where the pedestrian presses the button, waits for the cycle to repeat, and gets the walk phase. The third type of signal does not have any walk phase. This type of signal is unacceptable, as the only way a pedestrian may ever get a green light is when an automobile on the side street activates the cycle.
  - *Are median refuge areas available?* Painted medians offer little refuge other than getting out of a lane of traffic. Substantive raised medians of significant width provide some increase in security for the crossing pedestrian and are required to meet LOS B and C standards for Street Crossings.
  - *Are there any amenities, including signage and design features, that strongly suggest the presence of a pedestrian crossing?*
  - *What are the intersection's sight distances?* Sight distance measures the unobstructed view between the motorist and the pedestrian. This can be a problem particularly when a driver intends to make a left turn under a permissive left-turn phase and it is difficult to see around the opposing left-turn vehicle. Sight distances can also pose a problem when parked cars are allowed too close to pedestrian crosswalks.
  - *Corner ramps may be either ADA standard or nonstandard.* The maximum curb radii allowed in Pedestrian Areas in Kansas City for an LOS A through C standard is 6m.

APPENDIX C: PEDESTRIAN BRIDGES AND UNDERPASSES

Accessing a BRT station in the center of the road can be a challenge. Crossing at-grade over multiple traffic lanes has inherent safety issues and may be a psychological disincentive to using the BRT facility. However, solutions that require pedestrians to climb up and down stairs can be physically difficult, dangerous, and oft ignored in favor of the shorter route. Elevators and ramps partially mitigate this, but at considerable expense.

At-grade crossings should always be the first choice when designing a BRT station. Only if this is physically impractical should a bridge or tunnel be considered. For example if the BRT station is combined with a Metro station, a tunnel makes sense. If the station is in the center of an expressway then access can be combined with an existing overpass. But if the station is on a street with traffic signals, chances are pedestrians will want to cross at grade. In general bridges and tunnels will only be used if there is a reason to go up or down, they lead directly to a shopping center or Metro, they are inviting, and crossing the street is overtly dangerous.

All too often pedestrian bridges have been constructed supposedly for the safety of pedestrian. The real reason though was to remove people from the roadway in an effort improve vehicle flow and speed. This is sad given that the people who need the safety of bridges the most – the elderly, those with disabilities, children in strollers – cannot climb stairs.

Following is a list of planning consideration for pedestrian bridges and tunnels.

- **crossing time –** if the bridge or tunnel makes it quicker to cross to the station, then people will use it. If the bridge makes it slower, people will try to find a shorter route. 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.[5]
- **vehicle speed, volume, number of lanes and median –** if the street to be crossed has the look and feel of an expressway, then people will naturally want to avoid it. If the street has lower speeds and volumes, fewer lanes, a tree-lined median, and/or signals then people will be inclined to cross at-grade.
- **traffic signals –** if there is a traffic signal within 200m of the crossing location, then gaps will be created in traffic such that people will not use the bridge.
- **street network –** if the street network funnels people to a bridge or tunnel, then they will be more inclined to use it. If the network is more of a grid system with multiple paths, then people will want to cross the street as soon as they get to it.
- **grade change –** if there is a reason for people to go up or down (hillsides, shopping center entries, Metros), they will be amenable to using a bridge or tunnel.

Following is a list of basic design considerations for bridges and tunnels.

- **lighting –** bridges and tunnels should be well lit.
- **visibility –** there should be clear lines of sight between the bridge or tunnel, station and street. This is a huge issue for security.
- **width –** bridges and tunnels should be wide enough to accommodate the peak hour number of people.
- **ramps, escalators, or elevators –** the bridge or tunnel should be accessible to a person in a wheelchair, a person pushing a baby carriage, a person with a bicycle or packages,

5 Moore, R.L. and S.J. Older. "^ Pedestrians and Motor Vehicles are Compatible in Today's World," Traffic Engineering, Vol. 35, No. 12, Sept. 1965, in "A Review of Pedestrian Safety Research in the United States and Abroad", Publication No. FHWA-RD-03-042, January 2004, pp. 97.

or one who has trouble climbing stairs. In addition there should be stairs for those who choose to use them.

- **flooding –** tunnels must include a good drainage plan.
- **criminals, vendors, graffiti, homeless, toilets –** if the bridge or tunnel is perceived as unsafe or unclean it will not be used, regardless of the design.

The following images show some issues with pedestrian bridges including design, placement and usage.

Walter Hook

Traffic stopped at signal makes crossing at grade easy; pedestrian bridge not well used
Jakarta, Indonesia

Lloyd Wright

Pedestrian bridge crowded with vendors thus limiting and discouraging passenger use
Dhaka, Bangladesh

Michael King

Multiple medians make crossing at grade easy; pedestrian bridge not well used
Mexico City, Mexico

Lloyd Wright

Steep, narrow stairway makes for poor accessibility to the transit station
Beijing, China

The following images show pedestrian bridges and tunnels that are well designed, located and used.

Michael King

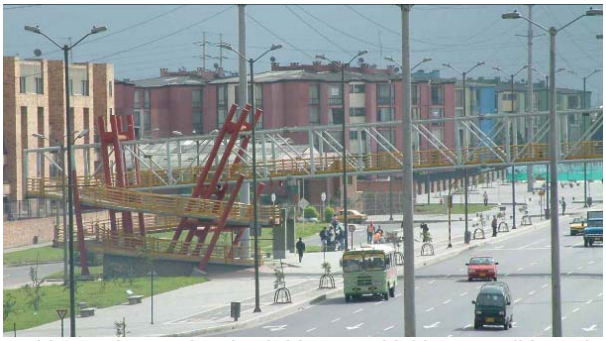
Park-like pedestrian bridge over an expressway
Guangzhou, China

Michael King

Park-like pedestrian bridge over an expressway
Guangzhou, China

Courtesy TransMilenio SA

Wide, modern pedestrian bridges are highly accessible and are well regarded by passengers
Bogota, Colombia



Lloyd Wright

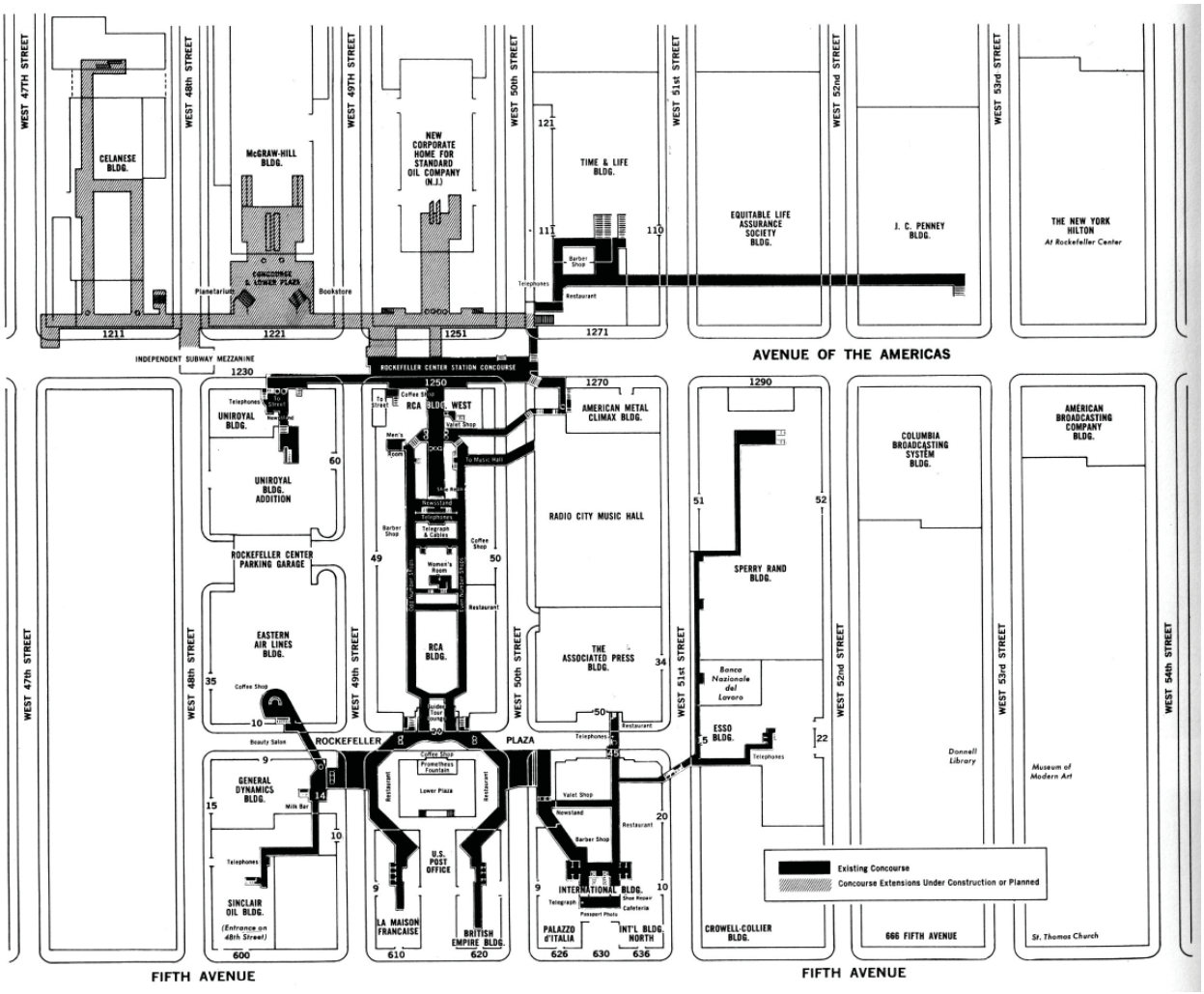
Wide, modern pedestrian bridges are highly accessible and are well regarded by passengers
Bogota, Colombia

Michael King

Pedestrian bridge connects directly to shopping center
Shenzhen, China

Michael King

Pedestrian bridge over an expressway connects directly to a school
Fort Worth, Texas (USA)

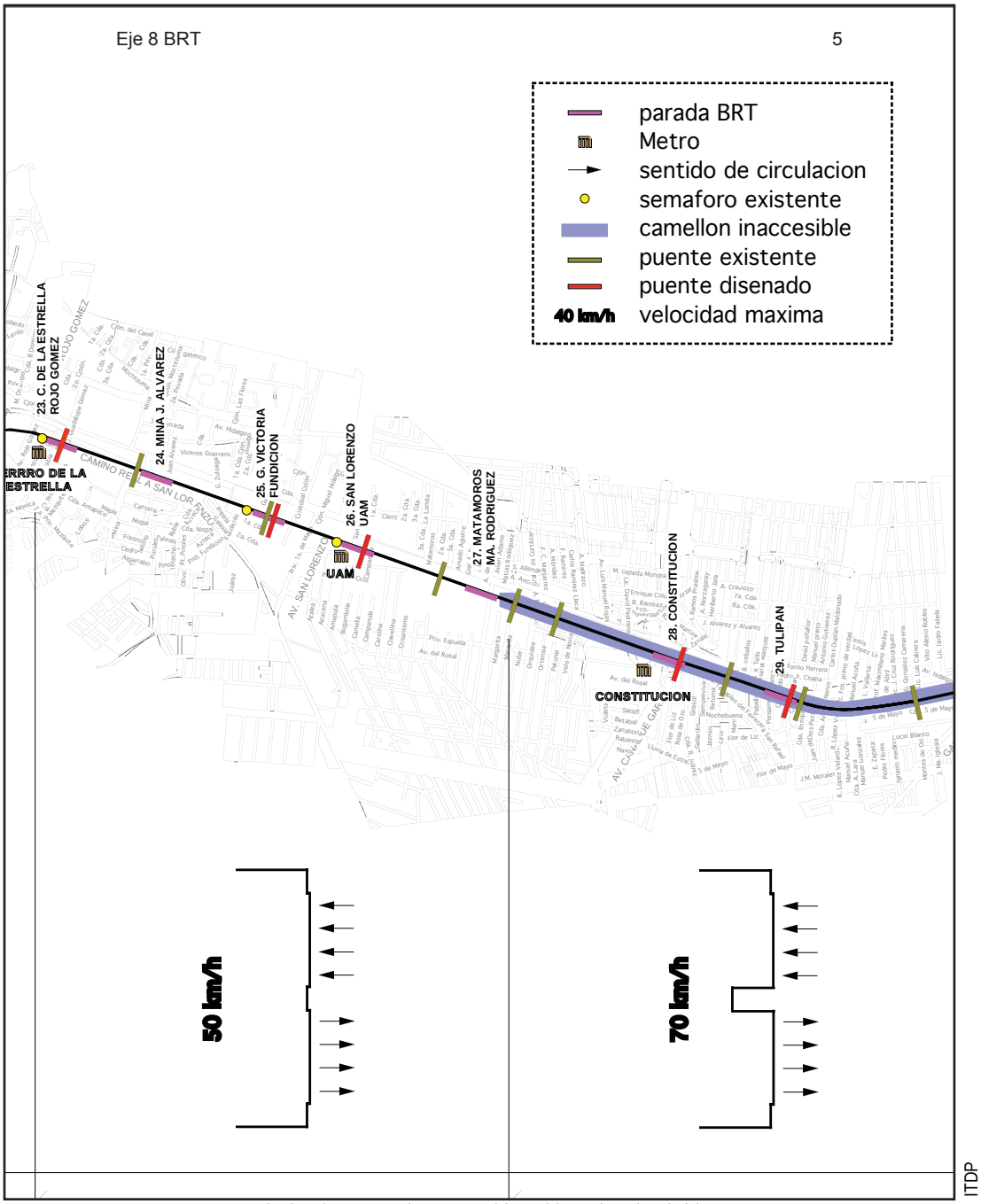


Underground pedestrian network at Rockefeller Center
New York City (USA)
Urban Space for Pedestrians, Pushkarev, B, Zupan, J., MIT Press, Cambridge, 1975

Michael King

Well-lit pedestrian underpass
Munich, Germany

The map below is from an analysis of the proposed *Eje 8* BRT corridor in Mexico City. Shown are the proposed stations, existing and proposed pedestrian bridges, traffic signals, speed limit, number of lanes, median type and street network. From this map one can see where bridges are necessary (where the Metro travels down the median), where bridges are not recommended (near underground Metro stations), and where bridges would be not used (where the street is relatively narrow and has traffic signals).



Analysis of proposed BRT corridor with pedestrian bridges
Mexico City, Mexico