Available online at www.worldscientificnews.com

World Scientific News

WSN 74 (2017) 36-52 EISSN 2392-2192

# Effect of Bike Lane Infrastructure on Ridership

**Tomas U. Ganiron Jr**

IPENZ, Auckland City, New Zealand

College of Architecture, Qassim University, Buraidah City, KSA

E-mail address: tomasuganironjr@gmail.com

**ABSTRACT**

This study addresses the use of non-motorized transportation. The global benefits of the bike paths, bike lanes, and other types of bicycle-specific infrastructure consist of a reduction in traffic congestion and a decrease in emissions of greenhouse gasses and other pollutants that commuters face today. Additional indirect benefits, of no less value, demonstrate the benefits and viability of bicycles and non-motorized transport. These findings suggest that lack of pollutions and low cost of this form of transport for commuting will encourage the adoption and development of similar facilities elsewhere around the world.

***Keywords*:** Bicycle lane, bicyclist, cycling, non-motorized transport, transportation engineering

## 1. INTRODUCTION

Growth in population and employment will increase transportation demands in the city of Manila. The increased demand, coupled with car ownership, will boost greenhouse gas emission plus all those traffic unless alternative measure to control their emission and rush hour traffic are developed and successfully implemented at an early stage.

Metro Manila is a massive urban area that is made up of 17 municipalities and accommodates about 11 million people, which covers about 800 square kilometers, for exceeding its administrative area. Its population has grown rapidly in the recent year (Ganiron, 2014). By 2019, Metro Manila is expected to become a massive conurbation of 13 million. As Metro Manila becomes more and more densely inhabited, gradually changes.

Dwellers move to outer areas while commercial and business developments take their place. With more household opting to live outside the inner area of Metro Manila, and with jobs and schools farther away, the number of trips and trip distances is expected to increase.

Moreover, economic prosperity has accelerated motorization and the demand for mobility, causing severe traffic congestion and serious air pollution, particularly in the inner areas. Without effective action, these problems will worsen over time as the area continues to grow. Residents currently rate traffic congestion as the number one quality of life problem, and air pollution, mainly caused by motor vehicles, as problem number two.

Increased demand coupled with increased car ownership will boost greenhouse gas (GHG) emission unless alternative measures to control these emissions are developed and successfully implemented at an early stage. Moreover, while more than 2 percent of all trips in the City of Manila are now bicycle, the anticipated increase in traffic and pollution will likely cause the disappearance of this mode of transportation. This pattern is already experienced in inner Metro Manila, where bicycles have been crowded out.

## 2. HISTORICAL BACKGROUND

The bikeway or bicycle path should conform to the predominantly accepted engineering standards for functionality, safety, and serviceability. Functionality refers to the bikeways utilitarian purpose for the system, which is to provide a means for a bicycle to ply the routes as a viable means of transportation (Taylor & Scuffham, 2012). The bikeway should also be safe for those who will use it to prevent any injury arising from accidents or fault in design. Serviceability refers to the ability of the infrastructure to provide the required quality service within the projected service life (Aultman, 1997). The mainly pertains to the durability of the structure against possible wear and tear arising from the direct usage of the facility.

The development of the bikeways system was introduced to countries having problems on traffic congestion and dense emission of greenhouse gas. Countries like the United States of America requires the State of California Department of Transportation (CALTRANS), a one-way lane and a two-way lane of a bicycle way (Axhausen, 1986). It has 2.4 meters width, two-way bicycle lane networks, which are connected to every commercial facility and 15 meters width for residential areas (Clarke, 1992). On the other hand, it has its own standard bicycle lane with a one-way lane 4.5-6 feet while two-way lane has 10-12 feet (Dixon, 1996). Furthermore, in New Delhi, the bikeway lane for the two -way lane is 2.5-3 meters. In Center for Research and Contract Standardization in Civil Engineering otherwise known as (CROW) of Netherlands adopted bikeway lane with according to the volume of traffic (Dathie, 2010). The effective pavement is 2.5 meters width in a one-way bikeway system for handling a volume of 150-750 bikes and 3.5 meters width for a volume more than 750 bikes per day (Farley et.al.,1996).

The California Department of Transportation (CALTRANS) requires a minimum thickness of 50 millimeters for asphalt paved bikeways and for concrete, a thickness that can sustain loads of maintenance vehicle (Forester, 1993). The design for the concrete pavement follows the usual design procedure of considering the load, the strength of concrete and modulus of subgrade reaction. The usual serviceability index is 2.5 and the required minimum steel reinforcement should be placed (Forester, 1994). The other design criteria for the pavement consists of the design speed for the bikes, superelevation, stopping sight distance,

the radius of curvature and friction factor. The CALTRANS adopts a design speed of 40 kilometers per hour, a friction factor of 0.25, a superelevation of 2.5 percent and a minimum radius of 52 meters (Goodnoet.al., 2013). At CROW, the design speed of 30 kilometers per hours, the stopping sight distance is 70-85 meters and a minimum radius of curvature of 20 meters (Harley, & Stewart, 1997).

## 3. RESEARCH DESIGN AND INSTRUMENTATION

### 3. 1. Research Design

The study used the inferential and descriptive methods of research with questionnaires as the main data-gathering instrument. The subjects of this study were the present situation of traffic in Manila. There are three types of descriptive methods used in this research. Namely, (1) a case study which is based on the observation to find out if the traffic situation in Manila is really congested and if the acquisition of greenhouse gas is too much. (2) a feasibility study to have a comprehensive, extensive and systematic analysis of all factors that might be needed to find the variability or possibility of the success of the proposed project, and (3) a survey method to have a systematic examination of the situation in order to collect data through questionnaires, the opinions and views of the respondents are carefully examined.

The researcher used an accidental sampling technique. For instance, the interviewer randomly picks on the street on everyone who passes by on him. The sampling might give a biased statement against the topic. In this case, the researcher tried to balance the type of samples used and widen the area to spot a respondent.

There were 100 respondents, which is a random combination of males and females, ages range from teenagers to non-retiring age. They must be accessing scope vicinity of the project. Some answers, opinions, and views of the given population might be biased but the researcher tried his best to extract their real thoughts and knowledgeable about the study.

### 3. 2. Instrumentation

The researcher used primary and secondary data, Under clerical tools, file records, case studies, questionnaires and scheduled interviews to gather data on the feelings, emotions, attitudes and judgments of the subject. The second kind is a mechanical device, a tape recorder was used to record the verbal interview and camera for a photograph of the vicinity.

### 3. 3. Statistical Treatment of Data

All the data gathered treated using the following tools.

**Percentage**

The percentage score was computed by the number of responses divided by the total number of the subjects and the quotient multiplied by one hundred (Wilkinson et.al., 1994). This method was helpful in interpreting subjects and subgroups having unequal sizes as in the cases of the sample characteristics of the respondents (Victoria, & Litman, 2000).

The formula is

$$\% = (f/N) \times 100$$

where: f = frequency of responses
N = number of cases/responses

**Weighted mean**

The mean of the answers was determined to provide the average option. It was computed using the following formula (Rowe et. al., 1995) :

$$X = \sum (wx)/N$$

where: $\sum$ = symbol for summation
X = mean
w = weighted of each item
x = item value

This formula was used to quantify variables such as gender, educational attainment and if they are a bicycle rider.

**Table 1.** Respondents per sessions.

| Number of sessions | Male Percentage | Female Percentage |
|---|---|---|
| 1 | 14.29 | 85.71 |
| 2 | 65.38 | 34.62 |
| 3 | 60.00 | 40.00 |
| 4 | 50.00 | 50.00 |

**Table 2.** Ratio of cyclist.

| Cyclist | Number of sessions | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Rides bike | 76.19 | 76.92 | 60.00 | 65.00 |
| Doesn't ride bike | 23.81 | 23.08 | 40.00 | 35.00 |

**Table 3.** Educational attainment

| Educational attainment | Number of sessions | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| College graduate | 100.00 | 57.69 | 66.67 | 60.00 |
| Not a college graduate | 0.00 | 42.31 | 33.33 | 40.00 |

## 4. ANALYSIS QUALITATIVE INTERVIEWS IN EVALUATION

This research highlights the results of the proposed bikeways network that have significant implication for the proposed project. It should be clear that these implications pertain not just to the physical aspects of the bikeways network bust also on those aspects that have to do with intangibles such as issues of safety and security, access and continuity, political support, transport demand management, integrated transport, environment, sustained campaigns for public awareness and so forth.

All of the participants were aware of the horrible traffic and transport situation in the metropolitan area. However, most of them regarded the situation in Manila is a worst as the rest of metropolis. Local transport problems were generally related to rush how traffic. Traffic congestion and difficulty in getting a ride on public transport were cited as particular problems encountered within the city.

Many referred to motor vehicle operation as driving dangerously with reckless driving and drunk driving as characteristics descriptions. They specifically cited this danger as the main reason for not riding their bicycles on the highway.

There were also complaints raised against motorized as creating a public nuisance. These ubiquitous conveyances caused traffic jams, posed a danger to other road users with the unpredictable road maneuvers and generally flaunted all rules of the road. With their two-stroke engines often emitting black smoke, tricycles were also cited as creating much pollution as well as adding substantially to the motor vehicle traffic.

Some participants also cited bicycle users as sometimes behaving erratically on the road, weaving in and out of lanes and stopping suddenly, posing a danger to themselves as well as another road users.

While participants were generally aware of pollution caused by motor vehicles, it did seem to be a significant concern here in Manila. This was, for many, only a secondary reason for not driving a bicycle even though they acknowledged the environmental benefits of non-motorized transport. None of the participants mentioned climate change effects as a consequence of motor vehicle emissions.

Many participants cited the economic benefits of bicycling, saying that it would definitely by a cheaper way to get around. This may have been due to the proximity of the latest round of public transport fare increase, something that was mentioned during the Focus Group Discussion (FGD). This saving factor was most notable among the participants

from lower-income households, including transport workers, factory, and clerical office workers and from those with little disposable income such as the students.

The number one reason for not riding a bicycle or not riding more was a concern for personal safety. Many thought that riding in traffic was too dangerous. They tended to blame reckless motor vehicle drivers for this situation although, upon closer examination, it seems a general fear of mixing it up with motorized traffic, which may or may not is moving dangerously, that keeps people from riding on regular roads. This perceived risk of an accident is difficult to verify since data are not available. However, this risk can be more than offset by the exercise benefits that cycling can grant according to some recent studies. This speaks of both a suspect level of cycling skills as well as inexperienced in riding a traffic and should not be attributed entirely to bad driving. It is this concern for safety, whether justified or not, that bears heavily on the subsequent of the proposed bikeways network and its features.

Other reasons given for not riding more were: possible theft of the bike, unfeasibility of riding bike outside Manila, bad road condition including open manholes and canals, lack of facilities, no bicycle owned/no access to a bike, cultural constraints ( for young girls and women), too much work and to some extent, the weather

### 4. 1. Reactions for Proposed Bikeways Network

In general, respondents reacted positively to the proposed .bikeways network. They expressed the belief that such a network if implemented properly, would encourage people to the cyclist just like in foreign countries where they have such network. What skepticism was expressed and attributed to the usual sour griping to any new initiative by the government? Participants regarded implementation and a sustained cycling promotion campaign to be key to the success of the program.

People seemed to have no doubt that promoting bicycling in the city and building a bikeways network would redound to measurable benefits. Among those cited were a reduction in pollution from motorized vehicles, less traffic congestion, lower transport costs and promoting the general health of the population. These endorsements, however, were tempered by a concern over what the network would actually entail. Many respondents thought that only bikeways that were exclusively for non-motorized traffic would be safe enough to attract users. The only commuting cyclist participants in the FGD, however, expressed the fear that cyclist would be banned from the roads and relegated to bike paths although he himself thought that these would make cycling safe for most people. There was also concern that bike lanes on regular streets would take away road space from motorized vehicles.

Another concern was the cyclist's security, both for his/her person as well as for the bicycle. Many said that the network ought to be well secured with a highly visible police presence to discourage theft(bike snatchers). They also said that the bike paths should be well lit. A suggestion to prevent theft and to identify bikes was to register them (just like cars) and to even color code them according to which the section of the city the owner lived.

Many said that if the network were provided these basic features that more people would be attracted to cycling. However, they added that providing the infrastructure alone would be inadequate to promote cycling in a significant way. It was thought a sustained campaign targeted at specific sectors of the population would be needed as well. They coupled this with a suggestion for the city to look into the possibility of providing incentives for cycling, subsidizing cycling as transport and even assisting those who had no bike or

could not afford to purchase bicycles on easy terms. Also, they remarked that city officials should demonstrate the feasibility of using the network and show a good example by using bicycles themselves.

However, when asked if they personally would ride or ride more, some participants equivocated. This was the reaction of two youth leaders of the youth council. It was also evident that many thought the bikeways would encourage mostly recreational riding and bike commuting only to a limited extent.

Participants also said that certain facilities would be useful to have. Most important were facilities for secure bike parking, for which most participants said they would be willing to pay a nominal fee, and changing/shower facilities at work destinations. Another suggestion was putting up bike shops in every community to provide maintenance and repair services. Directional signs on the bikeways would also be needed to help people to get to their destinations.

Participants also said that the city should conscientiously maintain the bike paths and lanes, keeping away unwanted users such as motorized tricycles, motorbikes, and motorscooters. However, some said that the pedicabs (bicycle with sidecars) should be allowed to use network since the idea was to promote non-motorized transport, not just one person bicycles. Sidecars would enable whole families to get around the city in non-motorized mode.

Maintenance also meant keeping the paths and lanes debris and the road surface well paved and free of holes and cracks. There was also a suggestion that the help of neighborhood associations and community organization should be enlisted by the city in maintaining the network. People also wanted signs posted all along the network to help people to where they wanted to go. A suggestion was also made that someone at city hall ought to have full-time responsibility for the bikeways network.

Two particular constraints were cited as possible limiting factors top get more people to bike. One was bike ownership. Wage earners consider a bike purchase a relatively large investment. One factory worker said that only the relatively well-off among them could afford to buy a bicycle. The other constraint is cultural. Parents generally tell the daughters when they reach a certain age(usually when they become teenagers) to stop riding the bicycle because it is unbecoming for girls to do so.

The participants seemed to think that it was feasible for school children, both elementary and high school, to ride bicycles to school. However, they said that the children should first be taught how to ride safely; bike safety education should be a part of the school curriculum.

A desire has expressed the consultation with stakeholders to held the feasibility study and implementation of the project was imminent. Organized groups also wanted to be able to participate in the actual planning and implementation of a program to promote cycling in the city.

Due to the apparent acceptance of the idea of promoting cycling in the city, the FGD participants, particularly those belongings to originally organized groups, were asked if they were willing to help such a campaign and it what way they would be able to do so. Housing and neighborhood association members said they would be willing to help maintain those sections of the network that ran through their communities. Youth group representatives would also help raise awareness of the benefits of cycling and of using the bikeways network. Most of the others said they would be willing yo support such campaigns if the local

government and other groups initiated them. What seems clear is that there are many organized groups that might be tapped to push a bicycling campaign in the city

### 4. 2. Implications for the Manila Network

Safety was the primary concern of the FGD participants. The image of the two-ton hunk of steel moving down a hapless cyclist on a road chock full of the motor vehicle is difficult to suppress even though that picture may be far from portraying reality. Reliable data on such risk is difficult to come by so such a perception is difficult to verify. However, it is from this preconceived fear that the prescription of physically separating cyclist from motor vehicles arises, often voiced by non-cyclist and inexperienced cyclist.

It is clear that creating a totally separated bikeways network cannot be a panacea for the fear of accidents. What's more, experience has shown that such a totally separate network create problems of its own, the most serious being that the network fails to respond to cyclist need for direct routes to their destinations. Since circuitous routes increase travel time, it is only reasonable to expect users to abandon such routes, either wholly or partially as have happened in certain cases.

An additional problem is that a totally separate bike route network gives motorized vehicle road users a license to literally run off cyclists from the regular road network even in those places where it is perfectly legal for cyclists to use these roads. Such a network, therefore, only encourages aggressive behavior from motorized vehicle drivers and increases resentment on both sides.

A clear compromise is for the bikeway network to integrate bothe exclusive bike paths as well as marked bike lanes and unmarked bike routes on city streets. Users can then use both systems as parallel alternatives to gain access destination points in the city. Additionally, there may be the option certain side streets as exclusive links corridors.

There are other considerations, equally important, that the safety issue embraces, the most obvious being the general lament of bad driving habits. It is not obvious how the city can deal with this since driver education and the license is the responsibility of the national government. However, the city might be able to address the problem in another way, that is, by actually enforcing road rules and traffic laws, and in a consistent manner. The surprising behavior of drivers in the enclaves of Subic and Clark can only be explained by a perception that you can't get away with it. For the long term, however, it would best to include awareness of the rights of cyclists on road in general driver education.

In this regard, there is probably a need to inventory all laws, and ordinances that affect non-motorized travel on roads and special pathways. One obvious gap in the vehicle code is its disregard of non-motorized modes. This system of benign neglect can be workable at times and can even be advantageous to cyclists (crossing intersections on red to avoid the rush of accelerating motor vehicles) but instituting a waking system of traffic and transport management must formally take into account the rights and responsibilities of non-motorized road users.

It will not help the cause of promoting cycling if a blind eye is turned to the need for cyclists to upgrade their bike handling skills and teaching them proper road behavior. Cycling in traffic demands skills beyond being able to balance on a bicycle, In addition to basic handling skills, a good cycling education program should be able to impact proper road behavior and a good knowledge of road rules. The FCD participants thought it would be good to start teaching such skills to students and that it should be part of their curriculum.

The President of The Professional Cycling Association of the Philippines and an FGD participant said that their group could help organize and conduct cycling clinics.

The perception that the roads are full reckless driving may be partly the result of tax law enforcement and the absence of posted speed limits. Clearly, this then calls for enforcement of the law rather than shunting cyclists off to segregate bike paths. In fact, better law enforcement would result in an overall rise in safety statistics and a better image of community' s liability.

A significant factor that would enhance the safety of bikeway users is it builds in safety measures in the design. There is now a member of standard for designing various aspects of the infrastructure that can be adapted to suit local needs in Manila. However, extra care should be applied for handling points of conflict such as intersections, entry and exit points. Points of convergence of different modes, blind spots, and crosswalks.

Participants were also concern about bicycle users having the proper safety equipment, the most basic having a helmet. However, other equipment such as elbow and kneepads were maintained. There are probably more appropriate for children. However, whether such equipment actually enhances safety and whether to make their use mandatory are issues that advocates have been debating for some time now. It would be wise to look closely at these issues before advocacy requiring the use of particular safety equipment should be pushed.

**Table 4.** Potential for Fatality Reduction to Each Safety Measures

| Measure | Potentially Fatality Reduction (%) |
|---|---|
| Teaching riders to avoid common mistakes | 50 or more |
| Helmet use | 40-50 |
| Eliminate intoxicated bicyclists | 16 or more |
| Eliminate intoxicated automobile drivers | 16 |
| Enforce right time lighting requirements | 10 or more |
| Teach motorists to share the road with bicyclists | 5 or more |
| Infrastructure improvements | Significant |

There are similar measures together may significantly reduce the risk of accidents suffered cyclists. In the study of Hunter (2000), he shows the potential for fatality reduction related to safety measures and its reproduced as shown in Table 4.

However, since part of the problem is the public perception of those risks, it is important to communicate to the public the safety measures that the local government is putting in place. This public education component crucial for assuaging apparently widespread fears on the risks of cycling on public roads.

The issue of security was mentioned in relation to prevent bike theft. While it is not known what the incidence of bike theft is in the city, this was expressed as a major concern by the FGD respondents. Mothers were particularly afraid that their children's bikes would be snatched from them. They believed police visibility on the bikeways would prevent such thefts.

As reported above, participants were willing to pay a nominal fee for secure bike parking. Bike parking areas would generate income for park attendants. Otherwise, racks should be provided to which cyclist can lock their bikes. There are various issues related to providing what can be considered adequate parking facilities for bikes. Parking areas should be relatively secure, well lit for those out late, and preferably protected from inclement weather. The city government should see to it that areas regularly accessed by the public should provide secure bike parking facilities. Private building owners should be made to provide such facilities without cost to the public.

Based on participants' comments, a cultural taboo, against girls riding bicycles still seems to be observed. Even in these otherwise enlightened times, mothers continue to enjoin their daughters from continuing to ride bikes when they reach their teenage years. This is probably why people who ride bicycles in Manila predominantly male, according to participants owns observations Since women make up half of the population, it is important to address this issue at all the relevant levels to assuage the fears of mothers, to boosts the confidence of young girls to keep cycling, and to encourage mature women to take up riding bicycles as a way to improve their access and mobility options.

Based on the respondents' reactions, it seems that the primarily benefit that people expect from bicycling are economic it will be cheaper to ride bicycles for short trips than taking motorized transport. If, as implied by this, people will be switching to bicycles from public transport for at least part of their travel needs, then the desired environmental impacts might not be evident at least in the short run. Since the switching might not be significant enough to reduce the demand for public transport, the number of motorized vehicles, and hence the level of emissions from them, will not show any decline. Only if people switch from private automobiles to non-motorized modes can there be expected a significant impact on the environment?

However, such a switch will require at least two things to happen given the participant’s feedback. One is that there must be a compulsion for automobile users to make the switch. This can be achieved by a system of incentives. The other is the need to extend the network to cover the rest of the metropolitan area so that travel from Manila to destinations outside the city by bike can be continuous.

Providing proper bicycling facilities is like leading a horse to water, people cannot make the horse drink unless it wants to or is given a good reason to, There was a sense that the FGD participants approved of the bikeway idea in principle but getting them to ride bicycles would take something more. Many said that they needed assurance that the city government was committed to ensuring that their cycling experience would be trouble free.

Providing basic facilities would probably make the experience of those who already ride their bikes more pleasant. However, getting the general public to regard cycling as a serious transportation option will require a sustained information and promotional campaign. The FGD participants clearly acknowledged this need to make cycling in the city more attractive. After all, this involves behavior and people are generally reluctant to change unless the

benefits to them of such changes are clear and forthcoming. Seriously, pushing a bicycling campaign in the city requires thoughtful planning and implementation.

Subsidies or other incentives can be used to reward who use bicycles. This is to show that there is a socially preferred behavior with regards to transport choices and that society is serious about promoting that behavior. Providing financial incentives is a relatively new approach to increase cycling for short trips and employees can be invited to participate in such programs.

Proper maintenance of the bicycle network was also mentioned as important , (Stinson, & Bhat, 2003). The participants though this should consist of keeping the paths and lanes well paved, clean and clear of obstructions. As reported above, community groups said they would be willing to help in maintenance work. A clear manifestation of local government commitment to maintain the network might mean a signing an office or an official to be primarily responsible for this (Smith, & Walsh, 1988). In many bike-friendly cities, naming a local bicycle coordinator is usually taken as a sign of local government's serious intent at promoting bicycling.

In addition, the city should address the basic issue of access to a bicycle. Ordinarily, means providing people a way to own a bike in an affordable way and the World Bank has an experience in integrating a credit program for bike purchases in their bicycle promotion projects (Kendrick et. al., 2011). However, there may be alternatives to outright ownership of bicycles. Some cities in Europe and the US have tried bike rental programs with varying degrees of success (Khop, & Khattak, 1999). Bike pooling, bike coops, loaner programs and some such similar schemes ought to be looked into as well

**Table 5.** Frequency and percentage distribution of respondents based on nature of employment

| Nature of employment | Frequency | Percentage (%) |
|---|---|---|
| Government | 214 | 70.2 |
| Private | 91 | 29.8 |
| Total | 305 | 100 |

## 5. INFRASTRUCTURE AND CIVIL WORKS

### 5. 1. Drainage

The cross slope provides for the flow of water from the pavement into the gutters and road inlet which are appropriately designed to limit the spread of water over the traffic lanes. The recommended rainfall by AASHTO is 20-50 years for arterial roads (Litman, 2009). The drainage system of the proposed bikeway should tie up with the existing street drainage lines. Care should be exercised during the detailed engineering that the proposed drainage lines should not overburden the current drainage system.

### 5. 2. Delineators

The current study of cyclist pertaining to the establishment of the bikeway system is significant (Litman, 2004). Because of this, there is a need to provide the necessary infrastructure to protect both the cyclist and the motorist from accidents. Special lane delineators are necessary to enable some sort of lane exclusively and prevent the right of way infringement. These dilators can be in terms of plant boxes, concrete barriers, rubber beams or rumble strips, especially for areas where there, not enough space.

The other safety features are suitable for areas where there are natural features such as bodies of water, a cliff or a drop along or across the bikeway system. The safety feature can be in terms of adequate signage, fencing and lighting to prevent a fatal fall or to alert the cyclist of an impending accident. The fencing can be of metal, timber or chain link fences. Adequate height should be provided to prevent the accident but not to cover the vistas (Ltman, 1999). Utilities or facilities that are close to the bikeway system should be properly condoned with enough space or clearance to avoid any direct contact with them. Cars should be exercised on features which may result in injury to the cyclists.

### 5. 3. Lighting

As for the motorist, the cyclist should also have adequate visibility. This is especially true when the sun has set and the daylight is gone. Other occasions when the daylight is inadequate, lighting becomes necessary for the cyclist's safety. If lighting is found inadequate in some segments of the bikeway, the street lighting should conform to guidelines of Philippines Electrical Code Committee and the Institute of Integrated Electrical Engineers (Lott, & Tardiff, 1978). Depending on the pedestrian and vehicular traffic the illumination level is from 2.15 to 21.15 lux (lumens per square meter) (Liu, & David, 1993).

### 5. 4. Public Sheds

The purpose of parking shed is to provide the necessary cover for the bicycle and protect them from damage by rain and other airborne debris. The parking should be adequate in dimension to accommodate the full length of the bicycle and of adequate height for the cyclist. Security and lighting should be provided for the bicycles and the cyclists. Harness bars should be provided onto which the cyclist can securely lock the bicycles white they stand to their individual businesses (Love et. al., 2011). These sheds should also be free from flooding and the area equipped with sufficient drainage facilities to prevent flooding which may inconvenient the cyclists and damage of the bicycles. The minimum illumination facility is 150 lux (lumens per square meter) (Lusk et. al., 2012).

### 5. 5. Rest Areas

It is recognized that cyclists are very sociable. In this respect, the designated rest areas should have the facilities and features to promote a social atmosphere. Adequate space, likable landscape and relaxing atmosphere are among the necessary factors to be considered. In addition, the rest areas should have bathroom facilities, garbage receptacles, sufficient lighting and a cool ambiance characterized by lush vegetation and trees (Mariz, 1998).

## 5. 6. Civil Works

The following are work items or activities associated with infrastructure in the construction of bikeway system. These are concrete pavement, laying of asphalt topping, bicycle racks, installation of bicycle lane barrier and installation of hazard protection (Moudon et. al., 2005).

An example of designing a bicycle lane is the one-way protected bike lanes (or "cycle tracks"), and another is a two-way protected bikeway on the street's west side (Pucher et. al., 2010). Bikeways are separated by planted medians and could include bicycle traffic signals at each intersection, planners said. The other design included painted, unprotected bike lanes, either with parking on both sides or with a center turning lane (removing parking on one side)

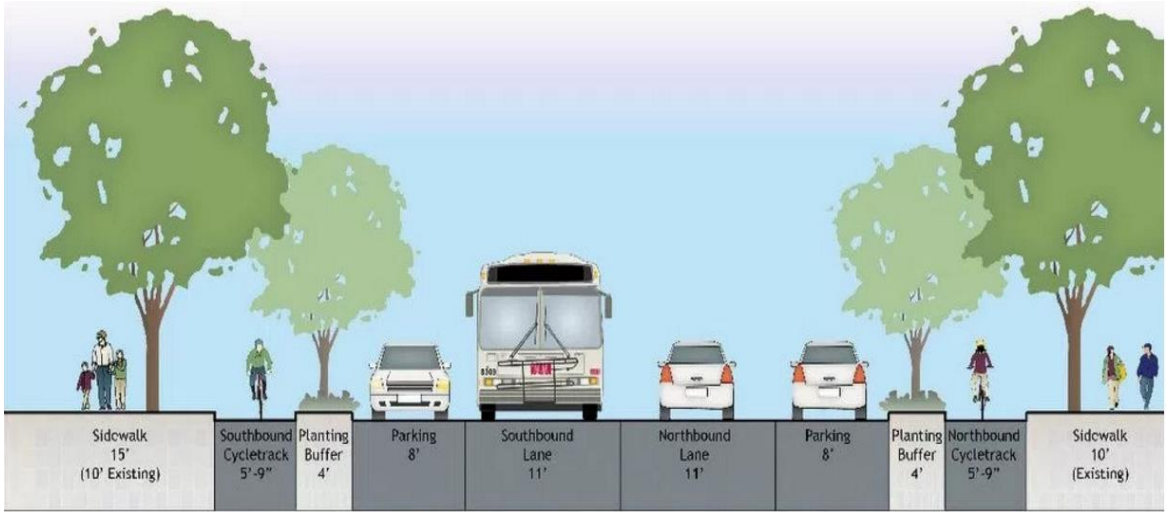


**Figure 1.** One-way cycle tracks

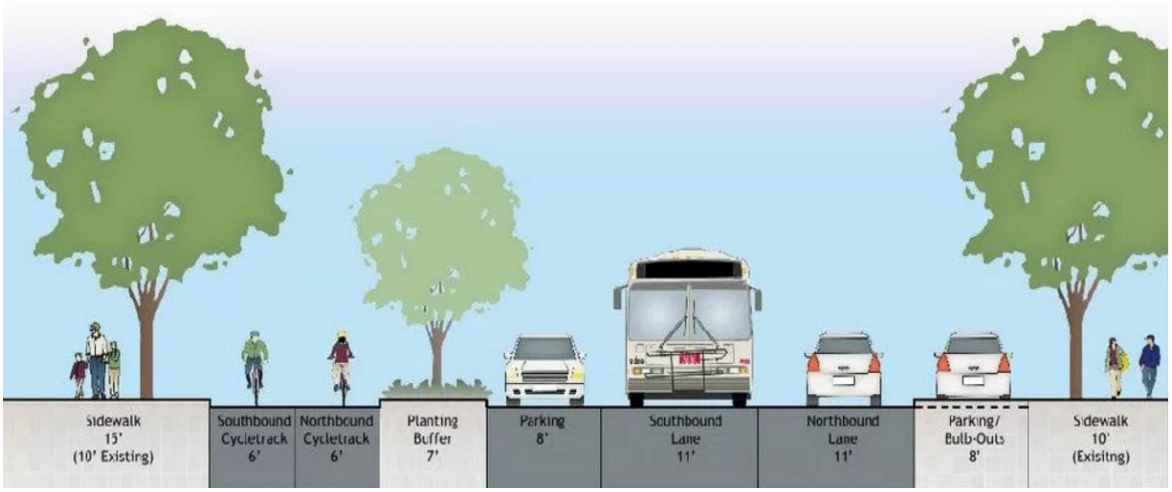


**Figure 2.** Two-way cycle tracks

With any of the alternatives, the street would get a road diet, with traffic lanes reduced to two. The street would have pedestrian safety upgrades along the corridor, like corner bulb-outs, curb ramps and raised crosswalks at alleyways. Both of the protected bike lanes would include bus boarding islands to the left of the bike lanes, meaning buses would stop in the traffic lane.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The long-term viability got increasing bicycling in Manila depends partly on developing a strategy to ensure its success. The process must be democratic and participative. In this context, participation from individual cyclist as well as organized cycling groups and other stakeholders should be solicited and welcomed. The most important thing a government can do is attempt to use its resources to meet the needs of cyclists rather provide when it thinks cyclists should want or should use.

Education should address the areas of skills training and behavior modification. This should consist of at least two levels: one for children, which will probably be coursed through schools; and one for a mature cyclist, which will consist of clinics. Awareness campaigns should aim to inform all affected sectors of the existence of the bike network. Part of this campaign might be drawing up of a city map showing bike routes and shared paths as well as rating streets on the criterion of appropriateness for bike travel.

An initial inventory of all levels and ordinances affecting non-motorized transport should be made and reviewed. New ordinances might be needed to regulate both cyclist and driver's behavior on the road as well as regulate the use of the bikeways network. Revisions to local building codes might be needed to mandate the inclusion of bike parking and changing facilities in all new constructions. Enforcement of traffic lanes will be a key to raising the safety profile of bicycle use in the city. Ensuring cyclist safety will be the foundation for increasing bicycle use in the city that will have the significant impact on emissions reductions.

Planning and engineering should be continuous efforts to ensure that the bike network and facilities meet the needs of users. One issue is integrating bicycle use with public transport. This might mean providing parking facilities at major public transport access points so that people can bike to these points from their homes and secure about leaving their bike until their return.

Engineering might also mean continually evolving standards that are appropriate to local conditions and use. This would include traffic signing, improving the design of facilities and monitoring problems.

Local governments that promote non-motorized transport also usually appoint a bicycle coordinator. The bicycle coordinator assumes full-time responsibility for managing the network and seeing to it that it is properly maintained, and responsible for policy formulation, raising funds to support specific aspects of the local program, and other tasks that relate to the network and campaign. Monitoring the performance evaluation system that will help the city to determine whether or not the investments it made are paying off and to an extent, they are paying off. These measures can also be used to build indices to show the quality of life in the city has been monitoring.

**Biography**

Dr. Tomas U. Ganiron Jr received the doctorate degree in Construction Management in Adamson University (Philippines), and subsequently received his Master of Civil Engineering major in Highway and Transportation Engineering at Dela Salle University (Philippines). He is a registered Civil Engineer in the Philippines and Professional Engineer in New Zealand. Aside from having more than two decades of experience as a professor, department head and researcher in the Philippines and New Zealand, Dr. Ganiron Jr is a practicing Civil and Construction Engineer for 20 years, having designed and supervised projects such as sewerage and waterworks structures, ports and marine structures, water treatment plant, and structural buildings and bridges. He is also very active in other professional groups like Railway Technical Society of Australasia and Australian Institute of Geoscientists where he became the committee of Scientific Research. He has received the Outstanding Civil Engineer in the field of Education given by the Philippine Media Association Inc. (1996), ASTM Award CA Hogentogler (2008) awarded by International Professional Engineers New Zealand and Plaque of Recognition as Outstanding Researcher (2013) given by Qassim University-College of Engineering.

## References


[1] Aultman-Hall, L. (1997). Commuter bicycle route choice: analysis of major determinants and safety implications.

[2] Axhausen, K. W., & Smith Jr, R. L. (1986). Bicyclist link evaluation: a stated-preference approach (No. 1085).

[3] Clarke, A. (1992). Bicycle-friendly cities: key ingredients for success. *Transportation Research Record*, 1372, 71.

[4] Dixon, L. (1996). Bicycle and pedestrian level-of-service performance measures and standards for congestion management systems. *Transportation Research Record: Journal of the Transportation Research Board*, (1538), 1-9.

[5] Duthie, J., Brady, J., Mills, A., & Machemehl, R. (2010). Effects of on-street bicycle facility configuration on bicyclist and motorist behavior. Transportation Research Record: *Journal of the Transportation Research Board*, (2190), 37-44.

[6] Farley, C., Haddad, S., & Brown, B. (1996). The effects of a 4-year program promoting bicycle helmet use among children in Quebec. *American Journal of Public Health*, 86(1), 46-51.

[7] Forester, J. (1993). Effective cycling. MIT Press.

[8] Forester, J. (1994). Bicycle transportation: a handbook for cycling transportation engineers. Mit Press.

[9] Ganiron Jr, T. U. (2014). Investigation on the Use of Sosrobahu Technology as Road Construction Technique. *International Journal of Advanced Science and Technology*, 65, 27-38.

[10] Goodno, M., McNeil, N., Parks, J., & Dock, S. (2013). Evaluation of Innovative Bicycle Facilities in Washington, DC: Pennsylvania Avenue Median Lanes and 15th Street Cycle Track. *Transportation Research Record: Journal of the Transportation Research Board*, (2387), 139-148.

[11] Harkey, D., & Stewart, J. (1997). Evaluation of shared-use facilities for bicycles and motor vehicles. *Transportation Research Record: Journal of the Transportation Research Board*, (1578), 111-118.

[12] Hunter, W. W. (2000). Evaluation of a combined bicycle lane/right turn lane in Eugene, Oregon (No. FHWA-RD-00-151,).

[13] Kendrick, C., Moore, A., Haire, A., Bigazzi, A., Figliozzi, M., Monsere, C., & George, L. (2011). Impact of bicycle lane characteristics on exposure of bicyclists to traffic-related particulate matter. *Transportation Research Record: Journal of the Transportation Research Board*, (2247), 24-32.

[14] Klop, J., & Khattak, A. (1999). Factors influencing bicycle crash severity on two-lane, undivided roadways in North Carolina. *Transportation Research Record: Journal of the Transportation Research Board*, (1674), 78-85.

[15] Litman, T. (2009). Transportation cost and benefit analysis. Victoria Transport Policy Institute, 31.

[16] Litman, T. (2004). Economic value of walkability. *World Transport Policy & Practice*, 10(1), 5-14.

[17] Litman, T. (1999). Traffic calming: benefits, costs and equity impacts. Victoria, BC,, Canada: Victoria Transport Policy Institute.

[18] Lott, D. F., & Tardiff, T. (1978). Evaluation by Experienced Riders of a New Bicycle Lane 1n an Established Bikeway System.

[19] Liu, X., & David, L. (1993). Operational analysis of bicycle interchanges in Beijing, China. *Population (Millions)*, 10(6.142), 3-570.

[20] Love, D. C., Breaud, A., Burns, S., Margulies, J., Romano, M., & Lawrence, R. (2012). Is the three-foot bicycle passing law working in Baltimore, Maryland? *Accident Analysis & Prevention*, 48, 451-456.

[21] Lusk, A. C., Furth, P. G., Morency, P., Miranda-Moreno, L. F., Willett, W. C., & Dennerlein, J. T. (2011). Risk of injury for bicycling on cycle tracks versus in the street. *Injury prevention*, 17(2), 131-135.

[22] Moritz, W. (1998). Adult bicyclists in the United States: characteristics and riding experience in 1996. *Transportation Research Record: Journal of the Transportation Research Board*, (1636), 1-7.

[23] Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L., & Weather, R. D. (2005). Cycling and the built environment, a US perspective. *Transportation Research Part D: Transport and Environment*, 10(3), 245-261.

[24] Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: an international review. *Preventive medicine*, 50, S106-S125.

[25] Rowe, B. H., Rowe, A. M., & Bota, G. W. (1995). Bicyclist and environmental factors associated with fatal bicycle-related trauma in Ontario. *CMAJ: Canadian Medical Association Journal*, 152(1), 45.

[26] Smith Jr, R. L., & Walsh, T. (1988). Safety impacts of bicycle lanes (No. 1168).

[27] Stinson, M., & Bhat, C. (2003). Commuter bicyclist route choice: Analysis using a stated preference survey. *Transportation Research Record: Journal of the Transportation Research Board*, (1828), 107-115.

[28] Taylor, M., & Scuffham, P. (2002). New Zealand bicycle helmet law—do the costs outweigh the benefits? Injury Prevention, 8(4), 317-320.

[29] Victoria Transport Policy Institute (BC), & Litman, T. A. (2000). Pedestrian and bicycle planning: a guide to best practices. the Institute.

[30] Wilkinson, W. C., Clarke, A., Epperson, B., & Knoblauch, R. (1994). Effects of bicycle accommodations on bicycle/motor vehicle safety and traffic operations.

( Received 22 April 2017; accepted 08 May 2017 )