# Policy Implications of Increasing Motorization for Nonmotorized Transportation in Developing Countries: Guangzhou, People's Republic of China

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Increasing motorization in developing countries may have positive or negative implications for urban mobility, mainly because of potential conflicts with the predominantly nonmotorized transportation in these countries. The potential for improved planning to avoid conflicts between these two increasingly important types of travel modes is considered. The most common difficulty in planning to reduce conflicts between motorized and nonmotorized transportation lies in the phenomenal growth in automobile ownership that has occurred in the last 10 or 20 years. Urban planning in Guangzhou (formerly Canton), China, located near Hong Kong is used as an example of planning to accommodate this phenomenon. Pooled accident data for 1989 and 1990 are used to illustrate the complex relationship between various types of collisions and traffic accident severity. Most traffic accidents in Guangzhou appear to reflect relative probabilities associated with purely random occurrences (unplanned and undesired outcomes). Some types of accidents, including those involving two automobiles or two motorcycles, were more severe, as measured in terms of the ratio of personal injury to fatality accidents, than was expected, relatively speaking, on an a priori basis. This suggests that drivers of automobiles and motorcycles in Guangzhou are less well prepared for the worst types of accidents than are pedestrians or bicyclists, and that this lack of preparation is independent of any conflicts that may arise between motorized and nonmotorized traffic. The random component of accident severity nonetheless predominates overall, with the end result being that pedestrians and bicyclists are much more likely than those in automobiles or on motorcycles to be injured or killed when traffic conflicts leading to collisions between motorized and nonmotorized modes of travel do occur. Methods to reduce conflicts between motorized and nonmotorized modes of travel under increasing motorization may include education, experience, or the construction of physical barriers through grade separation. Because of the high cost of grade separation, however, it has been used only sparingly in most developing countries. There are some exclusive bicycle lanes in China, as well as some separated bicycle parking facilities, but not many. Other strategies of possible use in developing countries include the identification of truck-free areas or time periods and the creation of automobile-free zones in commercial or residential areas. In terms of controlling the rate of growth in automobile traffic and determining where such growth should occur, improved zoning regulations for automobile parking and the use of fees and licensing for road access may be used. In terms of safety, improved driving rules and better lane marking are important considerations. Travel demand management, in the form of comprehensive land use plan elements and zoning regulations that encourage employer actions to promote alternative modes of travel, might be considered.

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The level of motorization continues to increase rapidly in developing countries around the world, and this does not by any means exclude the People's Republic of China. China has undertaken a massive road building program as part of its overall economic development strategy, with the total mileage of the national highway system increasing from just 75,000 km in 1949 to well over 1 million km in 1988 (*1*). This yields a total increase over 39 years of more than 1,250 percent, or an average increase of about 7 percent a year in the total length of the national highway system. In the 1970s, increasing emphasis was placed on the construction of higher-quality divided highways; in the 1980s the first grade-separated expressways in China were built.

The result of this frenetic construction activity has been the beginning of a national network of paved, signalized, and latterly exclusive right-of-way highway facilities. The main purpose of this exercise has been to move goods by truck from one city to another more efficiently and effectively, with greater speed and timeliness, providing a higher level of service and more flexibility in the operations of major industrial producers in China. As an indirect consequence of the development of this new national highway system, private automobiles slowly are becoming more attractive to those who can afford them in China. With the increasing liberalization of the economic system, more and more inhabitants of China will gain both the ability and the desire to purchase more sophisticated and more expensive consumer goods, including private automobiles, vans, and motorcycles.

Nonmotorized traffic has its own problems in developing countries. Pedestrians and bicyclists often make up a large part of urban traffic in developing countries, and China is no exception to this rule. Ironically, because of the relatively low incomes of most of the people living in China, bicycles are much more popular alternatives to public transportation than are private automobiles, motorcycles, or even mopeds at this time. Thus, in Shanghai the bicycle is considered to be the principal cause of the noticeable decline in public transit market share occurring in recent years, and of the concurrent rise in the level of traffic congestion on many local streets in

China's largest city (*2*). There is a high level of dependence on bicycle transport in Guangzhou (Table 1).

Public transit may take many forms in developing countries, including the traditional subway, elevated, light rail, and large bus systems so often found in developed countries, as well as a wide variety of paratransit services based on rickshaws, jitneys, taxis, minibuses, and the like, which are more varied as well as more common in developing countries (*3*). In China the highest priority is still being placed on increasing the capacity and maintaining the overall urban market share of public transit in large cities (*4,5*). This is not unlike that of urban transit officials in more capitalistic developing countries such as Brazil (*6*).

Increasing motorization has resulted in concerns being expressed in China over where to park all of the private vehicles now being bought or otherwise brought in to use all of the new roads that have been built in the past 20 years (*7*). Given the rapid population growth in urban areas, often accompanied by even faster growth in vehicle ownership and travel, developing countries often exhibit much worse traffic congestion than do older or more established cities in the developed world. Responses to the problem of traffic congestion in developing countries might include one or more of the following:

1. Do nothing—let the market prevail;
2. Implement travel demand management strategies;
3. Improve traffic safety conditions;
4. Develop new transportation facilities;
5. Regulate land use through zoning; and
6. Carry out general urban development policies.

This paper is concerned with identifying recent trends in travel, in reviewing past planning practices, and in making certain recommendations for improved future planning with respect to transportation in a particular city of China, Guangzhou.

**TABLE 1 Guangzhou Modal Split, 1984 and 1989**

| | Mode Split | |
|---|---|---|
| **Mode of Travel** | **1984** | **1989** |
| Non-motorized | | |
| Walking | 40.0 | 35.6 |
| Bicycling | 29.9 | 29.8 |
| Motorized -- public transit | | |
| Buses | 19.5 | 17.2 |
| Vans | 1.2 | 3.2 |
| Ferry boats | 2.2 | 2.0 |
| Motorized -- other vehicles | | |
| Private auto | 5.0 | 6.0 |
| Taxicab | 1.8 | 4.3 |
| Motorcycle | 0.4 | 1.3 |
| Other | 0.0 | 0.6 |
| Total | 100.0 | 100.0 |

Source: Guangzhou Urban Planning Bureau. Information for 1984 gathered from an original comprehensive regional origin/destination study, including a 3% sample of the total population, or 18,584 households and 60,911 persons surveyed. Estimates for 1989 are extrapolated from 1984 travel data, using 1989 vehicle registration data.

## RECENT TRENDS IN GUANGZHOU

Private ownership of the means of urban transportation in Guangzhou and indeed in all of China is limited primarily to bicycles and motorbikes. Except for a few dozen automobiles owned by individuals, motorized vehicles are generally owned by the government, government agencies, joint venture groups, or other government-sponsored or government-permitted groups. This situation is likely to change as restrictions on private ownership continue to be relaxed. In China the trend toward privatization of economic activities is not nearly as far along as it is in some other countries struggling with centrally planned economies, but it appears to be proceeding more rapidly in southern China, where Guangzhou is, than in many other parts of the country. Privatization generally is still referred to in China as a relatively small but rapidly growing component of the "planned commodity economy."

### Vehicle Registrations

The number of motorized vehicles in China has increased dramatically in the recent past. In Guangzhou alone the number of bicycles more than doubled and the number of motorcycles increased more than 40 times between 1980 and 1990. During the same period, the number of motor vehicles increased by almost 10 times (Table 2). The result of this increase has been a significant increase in traffic congestion and a growing number of conflicts between motorized and nonmotorized modes of transportation. Conflicts occur most often at intersections, at which bicycles and pedestrians, often with little or no regard for the danger involved, cross paths with motorized vehicles.

Observations of lifestyle, income, modernization programs, and local expressions indicate that the current reliance on the automobile will increase, especially for intercity transport. The government cannot continue to rely on water and rail transport for short-distance hauling and, in fact, is no longer doing so. Truck-induced traffic congestion is observed in and around many of China's urban areas. Furthermore, automobile use in Guangzhou is increasing rapidly for very similar reasons, just as automobile use in Western countries increased in the past because of the added convenience and flexibility of private automobiles. (Most "private" automobiles, as referred to in the West, are in fact owned and operated by the central government, government agencies, or local government offices. This does not by any means change the fact that publicly owned automobiles can and are used for many types of private activities, in China as in the rest of the world.) The automobile provides an air-conditioned ride, an important factor in the hot and humid climate of Guangzhou, as well as the ability to get to many places that are simply not accessible using public transit routes. Automobile rides are generally more comfortable and, except in areas of extreme traffic congestion, much faster than either bicycles or public transit for most trip purposes.

TABLE 2 Actual Number of Vehicles in Guangzhou, 1980 and 1990

| Type of Vehicle | Actual Number of Vehicles | | Change |
|---|---|---|---|
| | 1980 | 1990 | 1980-90 (%) |
| Bus | 1,825 | 6,644 | 264.1 |
| Car[a] | 5,971 | 26,977 | 371.6 |
| Truck[b] | 13,153 | 51,534 | 291.8 |
| Motorcycle | 3,593 | 157,677 | 4,288.4 |
| Bicycle | 1,039,426 | 2,669,130 | 156.8 |

Source: Guangzhou Urban Planning Bureau.
[a] Includes cars, vans and taxis.
[b] Includes large, medium and small trucks.

## Highway Safety

With the increase in automobile traffic in Guangzhou, regrettably, yet inevitably, has come a concomitant increase in the number of accidents involving property damage, personal injuries, and even fatalities. Whereas the total number of traffic accidents and fatalities increased dramatically between 1971 and 1990, the number of personal injuries related to traffic accidents grew much more slowly (Figure 1). The total dollar cost of traffic accidents increased by more than 700 percent between 1983 (when such records were first made public by the city) and 1990. The total annual number of traffic-related accidents in Guangzhou increased by 134 percent, and the number of vehicles, including bicycles, increased by only 118 percent between 1980 and 1990.

The more rapid increase in the number of traffic accidents may indicate increasing traffic congestion, as well as the lack of familiarity of many members of the general population with the particular abilities as well as the limitations of motorized forms of transport. These accident statistics may not reflect accurate measurements of true exposure, but nonetheless can be used as crude estimates of the relative risk of traffic accidents (*8*). A separate analysis was conducted of traffic accidents in Guangzhou in 1989 and 1990 by the type of incident, including collisions between each of the following pairs: vehicles and (a) other vehicles, (b) motorcycles, (c) bicycles, and (d) pedestrians; and motorcycles and (a) other motorcycles, (b) bicycles, and (c) pedestrians.

All other types of collisions, including multiple-vehicle collisions and any collision in which the travel mode of an involved party was not known, were excluded from the analysis. The seven specific types of two-party collisions identified in this analysis accounted for fully 72 percent of all traffic accidents reported in Guangzhou in 1989 and 1990 combined but only 53 percent of the personal injuries and 42 percent of the fatalities sustained during the same 2 years. Other types of collisions were much more likely to cause personal injury, especially death, than the seven types considered here. More than half of all traffic accidents, but only 10 percent of personal injuries and traffic fatalities, involved collisions between two motor vehicles (Figure 2).

The greatest number of traffic fatalities was associated with collisions between vehicles and bicycles, followed by collisions between vehicles and pedestrians (this excludes the "other" category). The ratio of accidents to injuries was similar to the ratio between accidents and fatalities across all types of collisions considered, including the "other" category (Figure 3). The ratio of personal injuries to deaths was lowest for collisions between vehicles and pedestrians, indicating that these types of collisions were the deadliest of those studied. The highest ratio of injuries to deaths was for collisions between motorcycles and bicycles, indicating that, although these types of collisions often resulted in personal injury, death was a much less frequent occurrence, relatively speaking.

Two-vehicle collisions resulted in personal injury or death relatively less frequently than did any other type of two-party

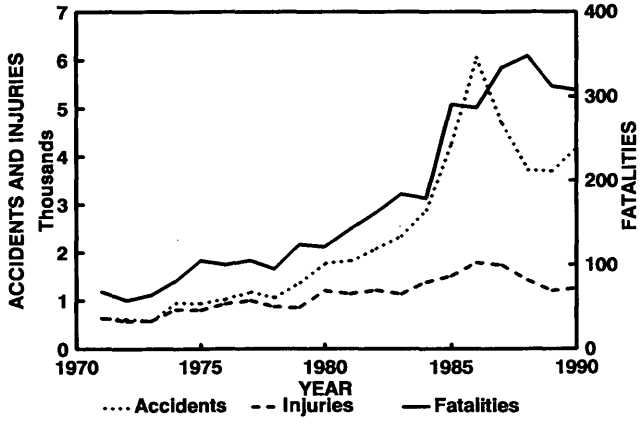


FIGURE 1 Traffic-related accidents, injuries, and fatalities in Guangzhou, 1971–1990.

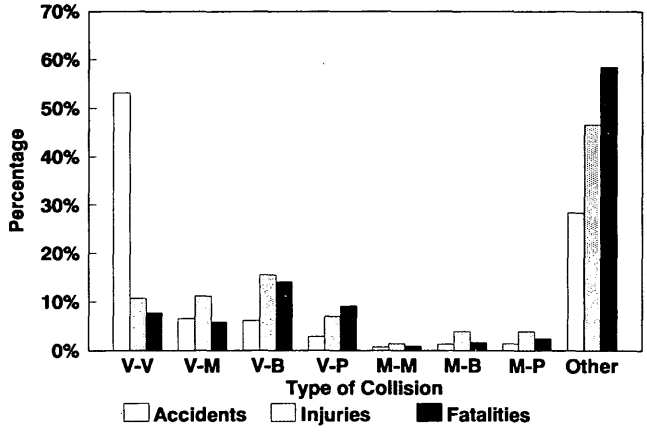


FIGURE 2 Distribution of traffic accident impacts by type of collision in Guangzhou, 1989–1990.

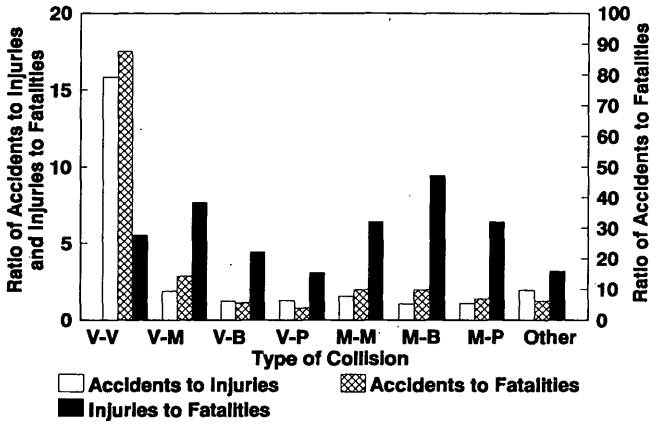


**FIGURE 3 Relative severity of traffic accidents by type of collision in Guangzhou, 1989–1990.**

collision. However, when some form of bodily injury was involved, it led to death in two-vehicle collisions more often than in any of the three types of two-party collisions involving motorcycles, but not vehicles (Figure 3). Only collisions between vehicles and bicycles or vehicles and pedestrians had lower ratios of personal injuries to deaths, indicating greater accident severity. These results suggest that the increase in deaths relative to personal injuries in Guangzhou between 1971 and 1990 may be due somewhat to an increase in the likelihood of traffic collisions involving larger vehicles, itself the natural result of increasing motorization. The ratio of cars to motorcycles involved in traffic accidents may have grown as well.

Because of data limitations, hypotheses such as these could not be tested explicitly in this analysis. Fridstrøm argues that traffic accidents should be treated primarily as random events, since they are usually not the result of intentional motivation (*9*). For Guangzhou, disaggregate discrete choice models probably would not provide better results in causal modeling than would aggregate statistical models and may in fact provide worse results, offsetting possible concerns regarding the "ecological fallacy" in inferential analysis. Under these conditions, our results should be fairly robust, at least at the aggregate level.

Monotonic decreases were expected in the relative frequency of traffic accidents, grouped by accident severity and type of collision, throughout the entire range of possible traffic conflicts. This was found to be true for most types of collisions, suggesting that the occurrence of traffic accidents in Guangzhou is primarily random in nature, and that the severity of accidents that do occur reflects the degree of inequality between the two colliding parties, as measured in terms of relative differences in mass and velocity (Figure 3).

The oscillation of peaks involving ratios of the most severe forms of traffic accidents—namely, those involving personal injuries and fatalities—is somewhat shocking in this regard. It may be that adaptive behavior on the part of the general population of the city to increasing motorization has resulted in the avoidance of some close calls, whereas more spectacular traffic accidents that result in death are not being avoided as successfully. It appears that as motorization has increased in Guangzhou, motorized travelers have developed their ability to avoid hitting others more rapidly than their ability to avoid being hit. This could be due to a lack of experience on the part of new drivers, compounded by the low starting point and rapid rate of motorization, with few local cultural antecedents to provide greater resiliency in the process of adaptation to changes in travel behavior and risk associated with motorization.

## Urban Growth

Despite official government policies aimed at severely restricting urban growth, the population of Guangzhou rose from just more than 3 million in 1980 to almost 3.6 million in 1990, an increase of greater than 18 percent. This rate of growth is projected to continue at least until the turn of the century, when the city's population is expected to be well over 4 million. A concomitant increase in the rate of motorization that occurred during the last decade would then result in more than 2.7 million vehicles in the city. However, the rate of vehicle growth appears to be growing at an increasing rate. Our best estimates, assuming no stringent government action to curtail growth, range from 3.0 million to over 6.8 million bicycles and from 280,000 to 7.3 million motor vehicles on the road in Guangzhou in the year 2000 (Table 3). To counteract this trend, the city government has decided to limit the number of new motorcycle licenses and issued only 6,000 a year.

In addition to the registered population, there is a large floating population in Guangzhou. The floating population consists of nonregistered rural migrants who flock to the city in search of better employment. Among other things, these migrants increase the demand for transportation, contributing to traffic congestion and increasing the number of potential conflicts between motorized and nonmotorized transportation. Although it is government policy to control migration, people continue to move into the city from outlying rural areas, with or without official approval. Only recently has any attempt been made to measure the travel demand characteristics of this rather elusive population group for comparison with the travel behavior of more established social groups within Chinese urban areas (*10*).

Except for the floating population, local government is in a good position to limit the effects of commuting on traffic congestion, because to a large extent housing is provided directly by the local government. The government determines the location of housing on the basis of official employment records (*11*). Some factories provide housing on-site, which reduces the number of trips made by workers. In other instances, workers' housing may be located at some distance from their place of employment, requiring lengthy commutes. Policies relating to on-site housing at places of employment apparently have limited the contribution of commuting to urban traffic congestion in the past. Future policies regarding on-site housing will require further study to predict the impact they may have on traffic volumes and congestion within the city. Far less stringent but perhaps equally effective controls on the location of housing may be observed in nearby Hong Kong, where much-more-prevalent private homes are built on land leased from the government (*12*).

**TABLE 3 Estimated Number of Vehicles in Guangzhou, 2000**

| Type of Vehicle | Estimated Number of Vehicles[a] | | |
|---|---|---|---|
| | Low[b] | Medium[c] | High[d] |
| Bus | 7,689 | 11,547 | 24,191 |
| Car[e] | 31,220 | 48,618 | 127,224 |
| Truck[f] | 59,640 | 90,609 | 201,910 |
| Motorcycle[g] | 182,478 | 314,545 | 6,919,497 |
| Bicycle[g] | 3,088,959 | 4,325,526 | 6,854,326 |

[a] Assuming no additional governmental limitations.
[b] Projected based on the number of transport vehicles per capita in 1990.
[c] Projected based on the ratio between the increase in population between 1980 and 1990 and the increase in the number of each form of transportation between 1980 and 1990.
[d] Projected based on the percentage increase in the number of transport vehicles in Guangzhou, 1980-1990.
[e] Includes cars, vans and taxis.
[f] Includes large, medium, and small trucks.
[g] In some cases, a particular method of projection may result in a figure that exceeds the projected population in the year 2000. The methodologies in question do not account for any decrease in the rate of increase that may occur as the market for one mode of travel becomes saturated, or as other modes of transportation from time to time become available or otherwise improve their competitive position.

Most personal income in China is controlled by the government and, by Western standards, is quite low per capita. However, there has been some relaxation of government controls on private sources of personal income to allow increased economic development to occur. The current policy on personal income allows limited buying and selling of private goods by individuals. Farmers are major recipients of increases in personal income under these relaxed rules. Farmers often spend extra personal income to buy private vehicles, which are used on the farm but may also enter the city from time to time, increasing the level of urban traffic congestion. Increases in personal income allow many more discretionary items to be purchased, including bicycles, motorbikes, and motorcycles. This has resulted in a large increase in the total number of private vehicles using public roads in Guangzhou.

### Physical Factors Affecting Transportation

The flow of traffic is limited severely by frequently narrow street widths within developed parts of the city. Major streets often are fairly wide, but intersecting streets just as often are quite narrow, especially in the oldest parts of the city. Even in areas of more recent development, narrow streets are still being constructed with some regularity. Exacerbating the traffic problems associated with the all-too-common overly narrow streets is the lack of setbacks from property lines in much of the construction occurring today. Structures quite often are built right up to the street line, which can and often does necessitate the removal of entire buildings to widen roads at a later date.

## PAST PLANNING ACTIVITIES

A 4-day symposium on traffic congestion and safety was held in Guangzhou in 1986 (*13*,p.52). Transportation officials from cities and provinces throughout China met to discuss traffic jams, speed degradation, and the rapidly increasing number of accidents occurring in Chinese cities during the early 1980s. These officials agreed that the following coping strategies might best serve to address these issues in the short term:

1. Improved traffic controls, such as a greater number of one-way streets, determined according to local traffic patterns.
2. Improved traffic regulations and facilities for cyclists.
3. Better equipment for traffic police, such as walkie-talkies to communicate problems to headquarters, and an incentive system to motivate traffic planners to do a better job.
4. Banishment from city streets of slow-moving vehicles, such as horse-drawn carts or tractors.
5. Better research and reporting of traffic volumes in cognizance of the fact that traffic jams tend to occur in specific locations at specific times. (Bridges and railway crossings were frequently cited as sources of recurring traffic congestion. Traffic jams sometimes involved hundreds of vehicles in lines of 1 mi or more, particularly in larger cities such as Beijing, Shanghai, Guangzhou, Wuhan, Shenyang, and Hangzhou.)

These generalized policy observations have since been developed into much more specific planning recommendations for the city of Guangzhou.

### Land Use Planning

The current Guangzhou Comprehensive Plan includes provisions for a wide variety of improvements to the regional transportation system. Some of the more important transportation provisions within the comprehensive plan include the following:

1. *Circumferential highways.* The highway element of the comprehensive plan shows several ring roads, the first of which is already under construction and partly open to traffic.
2. *Express highways.* Several toll facilities are included in the comprehensive plan. The road to Foshan, a city approx-

imately 20 km west of Guangzhou, is now open. A toll road linked to Hong Kong and Shenzhen is under construction.

3. *Subways.* The transit element of the comprehensive plan calls for the construction of a subway system focused on the city center. The feasibility study has been completed. Construction is projected to begin in 1993, subject to the availability of funding, some of which is still pending. The subway is expected to be 35.91 km long at build-out and will include 31 rail stations on two separate lines.

4. *Parking.* The traffic circulation elements of the comprehensive plan includes provisions for dozens of new parking lots and bus stations spread throughout the city, a few of which have already been built. The city has also adopted a few parking regulations. Unfortunately, these do not cover all existing categories of land use. Additional parking regulations are currently under development. Differences between current and proposed motor vehicles parking regulations are considerable (Table 4).

5. *Design standards for streets.* The city has adopted design standards for new streets under the comprehensive plan. These standards relate to the grading, cross section, width, and separation of motorized and nonmotorized traffic on new streets, which vary in stringency for different categories of streets.

6. *Tunnels.* The comprehensive plan includes provisions for several new tunnels, one of which is under construction beneath the Pearl River.

## Zoning Regulations

Until relatively recently, there was little need for the establishment of local land use zoning regulations anywhere in China. The central government retained ownership of all land and could address development issues directly, in any manner that would best suit national goals and objectives. Local autonomy and variations in local preferences were not considered to be relevant. The construction of new towns, the development of joint ventures, the encouragement of increased levels of foreign investment, and the reinstitution of private control of land on a limited scale all have increased the need for land use zoning regulations or other similar types of local controls on development. The national government recognizes the need for such local controls and has recently passed legislation authorizing—indeed, requiring—the development and implementation of various types of local land use zoning instruments. Guangzhou, like all Chinese cities, does not have its own comprehensive zoning laws fully in place at this time. Instead, the city, in conjunction with its technical advisor, is in the process of developing a more detailed set of zoning regulations. These new and more comprehensive zoning regulations will include some or all of the following:

1. Plans for traffic circulation, including greatly expanded parking requirements;
2. The creation of specific area planning land use districts;
3. Allowances for mixed use development;
4. Incentives for the provision of pedestrian ways and streets;
5. Permission for higher-density land uses near subway stations; and
6. Density controls and the regulation of traffic generators.

The proposed zoning regulations are far more comprehensive in scope, including motorized vehicle parking requirements for several types of land uses that are not covered by local legislation at the present time (Table 4). These new zoning regulations, which are still under development, are based on realistic projected increases in both population and vehicle ownership levels (Table 3). Design requirements for off-street parking and loading also will be included.

## Traffic Regulations

The city of Guangzhou has some fairly basic traffic regulations in place at this time. Drivers currently are required to

1. Undergo testing in order to be licensed,
2. Travel on the right-hand side of the road,
3. Travel within designated traffic lanes,
4. Abide by both general and posted speed limits, and
5. Obey all posted traffic signs and signals that control the flow of traffic.

In Beijing, separate traffic signals for automobiles and bicycles are common. In Guangzhou, this is not yet normal practice. Drivers are permitted to turn right without stopping

**TABLE 4 Motorized Vehicle Parking Requirements in Guangzhou**

| Land Use | Parking Ratio |
|---|---|
| First class hotels | Total number of guest rooms X 6 ($m^2$) |
| Ordinary hotels | Total number of guest rooms X 3 ($m^2$) |
| Restaurant, tea houses | Total floor area X 0.2 ($m^2$) |
| High class office buildings | Total floor area X 0.2 ($m^2$) |
| Ordinary office buildings | Total floor area X 0.1 ($m^2$) |
| Shopping center | Total floor area X 0.06 ($m^2$) |
| Financial and international trade complex | Total floor area X 0.2 ($m^2$) |
| Hospitals | Total number of beds X 2 ($m^2$) |
| Exhibition buildings | Total floor area X 0.2 ($m^2$) |
| Cinema, convention center | Total number of seats X 0.7 ($m^2$) |
| Gym and stadium | Total number seats X 0.7 ($m^2$) |
| Interesting and historical spots | Total area of land X 0.015 ($m^2$) |
| Parks, landscape spots | Total area of land X 0.006 ($m^2$) |

Source: Guangzhou Urban Planning Bureau.

at red lights in Guangzhou. There are a few areas of the city in which on-street parking is restricted or one-way traffic has been implemented. The city has set maximum noise levels for motor vehicles, on the basis of national standards. There is some separation of motorized and nonmotorized traffic. Major streets generally have separate bicycle lanes, although motorbikes and other small motorized vehicles often are observed using these lanes, which technically is not allowed. Bicycles sometimes are observed using lanes designated for motorized vehicles only. In some cities, animal-drawn vehicles have been observed using motor vehicle lanes, even though animal-drawn vehicles are prohibited from entering the city proper in all of the major cities.

## FUTURE PLANNING ACTIVITIES

Recommendations to help the city adjust to projected growth in private vehicles of all types were made in two major cat-

**TABLE 5 Land Use Management Recommendations**

| Technique | Current Status | |
|---|---|---|
| | Under Study | Partly in Place |
| Encourage more intense use around subway stations | o | |
| Provide for mixed land uses | o | o |
| Plan land uses such that these are closer to the population from which they draw | o | o |
| Plan/design roads specifically for automobile traffic | o | |
| Provide incentives for the construction of pedestrian ways | o | |
| Require that design review include consideration of pedestrian ways | o | |

**TABLE 6 Traffic Control Recommendations**

| Technique | Current Status | | |
|---|---|---|---|
| | Under Study | Partly in Place | In Place |
| License drivers | | | o |
| Increase traffic enforcement | o | o | |
| Facilitate carpooling | o | | |
| Restrict the hours of truck operations in downtown areas | o | o | |
| Limit the availability of parking | o | o | |
| Require in-structure or off-street parking and/or loading areas | o | o | |
| Provide bicycle parking areas | o | o | |
| Require curb cuts and setbacks: control distance between & location of access points | o | | |
| Separate traffic lanes | o | o | |
| Separate traffic signals for different modes of transport | o | | |
| Separate streets at-grade | | o | |
| Separate street segments for pedestrians, bicyles, and motorized vehicles | o | o | |
| Control street access | o | o | |
| Resolve intersection conflicts | o | | |
| Create auto-restricted zones | o | o | |
| Require and set development impact fees | o | o | |
| Allow private construction and operation of roads | o | o | |
| Establish and/or increase toll facilities, licensing fees, use permits, and/or gasoline taxes | o | o | |
| Land lease--allocate % to roads | o | o | |
| Adopt tax increment financing | o | | |
| Increase public awareness through education | o | o | |

egories: land use management (Table 5) and traffic control (Table 6). The specific recommendations range from siting land uses in relationship to the population being served, to traffic signalization improvements, increased use of one-way streets, and the creation of reserved bicycle parking areas. These recommendations were made for the following reasons:

- To promote the use of alternative modes of travel;
- To reduce conflicts between motorized and nonmotorized transportation;
- To identify and control required transportation infrastructure;
- To improve traffic flow, regulations, safety, and management; and
- To establish appropriate transportation pricing strategies.

These recommendations are in various stages of implementation: some are under study and others are in place partly or wholly throughout the city. In general, much work remains to be done in this area; the problem, which is still fairly new, is difficult to acknowledge as being likely to increase in scope dramatically in future years.

## CONCLUSIONS

Increased motorization more than likely is coming soon to China. In a sense, it is already there, at least in nascent form. On one hand, the overall level of motorization probably will remain low in China, at least by Western standards, for a very long time. On the other hand, the rate of growth in motorization is likely to remain high in China because of latent demand and a low initial starting point. Failure to recognize both the significance and the persistence of this trend, and to deal with it constructively, may result in severe problems in several areas, including the following:

1. Inappropriate land use patterns to accommodate future growth in both motorized and nonmotorized traffic;
2. Increasing dangers of personal injury and death to pedestrians and bicyclists, resulting from an increasing number of unavoidable traffic conflicts; and
3. Perhaps somewhat paradoxically, an even higher rate of growth in motorization than might otherwise occur, as a result of nonmotorized travelers' switching to faster and more convenient motor vehicles for a very different reason—safety.

China can avoid many of the most common mistakes that have occurred in the earliest stages of motorization by learning from and building on previous experience of countries such as the United States, Japan, and the European Community and taking those steps deemed to be necessary to mitigate the negative social, environmental, and energy impacts of automobiles. The first step is to improve traffic controls in anticipation of increased travel demand, so that traffic congestion does not lead to a loss of economic efficiency or reduced quality of life. The second step is to try to reduce the explosive rate of expansion in motorized transportation now being observed. Increasing motorization can be accommodated well only if it occurs at a gradual pace, to allow for the development of adequate infrastructure and to allow society time to make the necessary adjustments in lifestyle considerations and learning curves.

It is entirely feasible that China could go its own way in this matter, if it should choose to do so. It would appear that learning from the past experiences of others can produce ample rewards in terms of minimizing the many mistakes that are more likely to occur in an era of rapid change. Taking action at an early stage in the urban transformation process known as increasing motorization is very important for Guangzhou. By taking careful steps to promote appropriate mixed-use land development and to encourage demand management and supply enhancement strategies in the area of urban transportation planning and decision making, Guangzhou is at the leading edge of creating a more livable urban environment for both motorized and nonmotorized forms of transportation in developing countries such as China.

It is unlikely that the People's Republic of China will achieve levels of motorization equivalent to those in Western countries for decades. Yet, motorization is almost bound to occur, and at a relatively rapid pace at that. It is vital that transportation policy in China reflect the fact that nonmotorized transportation will remain important for many decades. Motorized transportation in China must be accommodated to nonmotorized transportation, rather than the reverse, if livable cities are to be created and maintained under these circumstances. Innovative and cost-effective solutions to the grade-separation problem, such as improved training and education on traffic safety, will most likely be important, given that diversity and complexity in urban travel markets is likely to be maintained for a lengthy period of time in China under current conditions.

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