Traffic Management in Bangkok

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ABSTRACT

Traffic congestion in Bangkok, Thailand, which has a population approaching 6 million, is a daily occurrence that involves many hours of wasted time for the residents, considerable waste of scarce fuel resources, and a deterioration of the environment through air and noise pollution. Although car ownership is relatively low in comparison with western cities, the road space per area is less than one-half that of most other capitals. The city's traffic congestion is being tackled by improvements and priorities to public transport, area traffic control, highway improvements, and law enforcement. The Office of Policy and Planning has been instrumental in reviewing alternative measures of traffic restraint and undertaking improvements to traffic signals. This began with the introduction of a microprocessor area traffic control system for the city center before the introduction of an areawide system. More than 100 km of with-flow bus lanes have been introduced to complement the contra-flow bus lanes, and these now provide the most extensive bus priority system of any city in Southeast Asia. The benefits to the high volumes of buses and minibuses that use these lanes are considerable. This has been complemented by comprehensive route improvement schemes on many of the main roads in the city and an extensive one-way system. Overall improvements to traffic flow have, therefore, been obtained in recent years which, together with the current plans for further major junction improvements and improvements to traffic enforcement and control, have led to the creation of a new traffic management initiative in Bangkok.

For many years traffic congestion has been a way of life in Bangkok, the capital city of Thailand. Despite the enormous cost of this traffic congestion in terms of resources and wasted time to the nation and the Thai people, it is tolerated and the city continues to survive and grow. However, if the level of traffic congestion is allowed to worsen it will undoubtedly have a detrimental effect on the city's development and future prosperity. The traffic congestion in Bangkok is not only severe, but also unpredictable. The same journey may take 30 min on one occasion and 2 hr on the next at a similar time of day and on corresponding weekdays. These conditions exist because much of the road network is operating close to capacity for most of the day (Table 1).

One of the factors that has contributed to this level of service pattern is that Bangkok has one of the lowest percentages of road space per area in the world. Bangkok's road space amounts to approximately 8.9 percent compared with 22 percent in London and 24 percent in New York. Furthermore, a large percentage of the total road space consists of minor dead-end roads, which only adds to the volume of cars on the few existing main roads. Under these conditions, small incidents such as breakdowns, short peaks in traffic flow, accidents, or storms can cause junctions to overload and complete stoppages to occur.

There are more than 700,000 motor vehicles registered in Bangkok, of which about 500,000 are in daily use on the roads. With the estimate of about 5 million people in the metropolitan area alone, there is a ratio of one vehicle being used daily per 10 people is relatively low in comparison to the United Kingdom where the ratio is four vehicles in daily use per 10 people. However, the increase in the volume of motor vehicles for the last 20 years in Bangkok has outpaced the population growth in the metropolitan area. In 1960 there were less than 100,000 vehicles for the 2 million people in Bangkok, whereas in 1970, that volume of motor vehicles had increased to about 300,000 for the city whose population had increased to 3 million. With increased real income each year and the city population continuing to rise, more vehicles will be on the roads and traffic congestion will spread to a wider area. The benefits to be derived from any improvement to the existing traffic congestion are potentially enormous.

The concern of the Royal Government of Thailand to alleviate, or at least contain, the level of traffic congestion has led to a number of studies and implementation measures over the last 10 years. New roads have been and are being constructed, but because of restrictions on the availability of funds and the limited scope for building new roads without widespread property demolition, this approach can

TABLE 1 Average Levels of Service on Typical Bangkok Roads

Level of Service	Description	Number of Hours Between 6:00 a.m. and 6:00 p.m.
A to C	Good travel conditions. Travel speeds declining slowly as traffic increases.	3.0
D	Deteriorating conditions. Travel speeds declining rapidly as traffic approaches road capacity.	3.5
E	Unstable travel conditions. Roads operating at capacity.	4.5
F	Forced flow conditions. Unstable traffic flow with frequent complete stoppages.	1.0

only provide solutions for particular areas. The Expressway, the Middle Ring Road, and Sathorn Bridge all provide relief in those areas but they are not likely to significantly reduce congestion levels throughout the city. It is clear from the experience of countries in other parts of the world that new roads generate new traffic, and any relief is only likely to be of a temporary nature.

Considerable efforts have also been and are being made to determine the feasibility, role, and effect of an appropriate mass public transportation system. However, it will be some years before the system, if appropriate, is realized, and costs are likely to be enormous. It is clear, therefore, that major investment projects in Bangkok will not provide the total answer to containment of the level of traffic congestion, and the Royal Government of Thailand has recognized this for some time.

In early 1978, the Thailand government reached an agreement with the World Bank for a loan to implement short- and medium-term traffic improvement measures and policies in Bangkok up to the mid-1980s. The implementation of the Bangkok Traffic Management Project (BTMP) includes

- Transport planning and policy,
- Area traffic control,
- Public transport measures,
- Route improvement, and
- Enforcement and training.

It was agreed in 1978 that within the Ministry of Interior, Office of Policy and Planning (OPP), a Committee for the Management of Road Traffic (CMRT) was to be provided with a permanent technical secretariat termed the Office of the Committee for the Management of Road Traffic (OCMRT). Thus, the OCMRT became the traffic planning authority for Bangkok, with further responsibility for coordinating transportation planning and policy in all parts of the country. Jamieson, Mackay, and Partners were appointed by the government to advise and assist the OCMRT.

TRANSPORT PLANNING AND POLICY

Traffic congestion can basically be addressed in a combination of ways. By increasing available road capacity, attempts can be made to accommodate existing and projected traffic demands or, alternatively, an attempt can be made to reduce traffic demand to such a level that existing roads can carry the remaining traffic. Road capacity can be increased by improving vehicle and driving standards, by traffic management measures, or by building new roads. Improving vehicle and driving standards and introducing widespread traffic management schemes must form part of the government's policy, but the overall effect on road capacity is likely to be relatively small and it will take years before widespread improvements can be achieved. It is unlikely that these improvements will even keep pace with increasing vehicle ownership and use. New roads are being constructed, but because of restrictions on the availability of funds and the limited scope for building new roads without widespread property demolition, these can only provide solutions for particular areas.

The alternative approach of trying to reduce traffic demands to a manageable level can be achieved either by traffic restraint, actively deterring motorists from using their vehicles, or providing alternative travel methods that may encourage drivers to change mode of their own free will and leave their vehicles unused.

Traffic restraint can produce rapid and significant effects. Although a small increase in the capacity of the road network may only generate new traffic and rapidly be taken up by increasing vehicle ownership and use, a relatively small reduction in traffic levels can produce large improvements in travel conditions. By removing 10 percent of traffic, average travel speeds for remaining traffic may increase by at least 25 percent.

POLICIES

Traffic policies may be considered under the headings (a) parking, (b) staggered working hours, and (c) traffic restraint.

Parking Controls

Parking controls are a policy measure designed to discourage the uneconomic use of low occupancy vehicles. They can specifically discourage long-term commuter parking, encourage short-term business parking, and remove obstruction to moving traffic. There is generally low priority attached to parking controls by the authorities as compared with other traffic problems, and the organizational structure does not exist for a comprehensive parking policy to be implemented. At the present time, only commissioned policemen have enforcement powers and the enforcement of extensive parking controls would employ a large number of officers who have been trained for much wider duties. The Bangkok Metropolitan Authority (BMA) attendants are only able to collect money and have no enforcement powers.

Despite difficulties in achieving a comprehensive parking policy and implementing this on the street, significant progress was achieved in August 1979. On orders from the Traffic Police Division and following consultations with the OCMRT, strict parking and loading prohibitions were introduced for morning and evening peak periods on 39 major roads in Bangkok. Enforcement levels have proved adequate, the public has accepted the scheme, and peak period travel has been greatly assisted. The success of this major parking control measure could lead to a wider application of similar measures within the city and to the eventual development of a comprehensive parking policy.

Staggered Working Hours

Staggered working hours are generally proposed as a method for spreading and reducing peak travel volume, and in Bangkok it was initially believed that this would be particularly advantageous for bus users. A number of surveys were carried out of both general traffic and bus passenger volumes, and these indicated that Bangkok does not, in fact, have the usual exaggerated peak travel pattern.

Traffic Restraint

There are many ways in which vehicle ownership or use can be restrained. For example, vehicle licenses and fuel taxes could be increased to such a level that only a small proportion of the population could afford to use a private vehicle. Or, all parking spaces could be so tightly controlled or highly

priced that only a portion of present-day travellers would be able to find parking spaces or be able to afford to pay the charge. These methods can be categorized as rationing, pricing, or indirect.

Consideration has been given to all appropriate methods of restraint, and Table 2 gives an overall evaluation of these methods. In 1980 cordon pricing (1,2), although it can overcome most problems, was ruled out by the government as impractical. By charging for the use of roads, motorists can be made to pay directly for the congestion costs to which they are contributing. Pricing can be applied only to the area where traffic congestion occurs--at the time of day when congestion is at a peak--and to selected vehicle types. For example, by charging private cars, people will be encouraged to use buses, thereby making greater economic use of the available scarce road space. With fewer people using low occupancy vehicles and more people using buses, it may be possible for more people (rather than vehicles) to travel in the previously congested area with traffic restraint than before. Cordon pricing has been shown to be possible in Singapore, and it is a flexible policy. The restraint cordon, charge levels, vehicle types to be charged, and period of operation, can all be adjusted if changes in the traffic situation occur.

As vehicle ownership and population size grow in Bangkok, all the methods of traffic restraint will have to be considered periodically to correctly balance the city's socioeconomic conditions. For a number of years, Bangkok has banned, except for the expressway, 6-wheeled lorries for 4 peak hr per day and 10-wheeled lorries for 10 peak hr per day. These bans significantly reduce urban travel costs and congestion. This form of traffic restraint is clearly practical and publicly acceptable, but continuing debate will be needed before an appropriate scheme can be identified to reduce the city's growing use of cars.

AREA TRAFFIC CONTROL

Significant improvement has been made in the traffic signal system; before 1978 much of the traffic signal equipment, both controllers and displays, was old and outdated. A key feature of the World Bank loan was the early approval of a negotiated contract with Traffic Engineering Systems Ltd. (TESL), in association with the General Electric Company (GEC), Elliott Traffic Automation Ltd., who, over a number of years had supplied virtually all of the existing equipment. This contract was for the supply and installation of a compact, microprocessor-based, Area Traffic Control (ATC) system, together with an extensive network of cableless linked controllers (Figure 1).

The contract was signed in April 1978 for the supply, installation, and maintenance of a GEC "highwayman" ATC system that would control 48 intersections in the old section of the city. The control center is located in the OPP building and is connected by the Telephone Organization of Thailand lines to GEC Type 25 intersection controllers. The system was completed on time and switched on in early May 1979 by the Minister of Interior.

During the first few months of operation, a number of amendments to the fixed time signal plans was needed, as traffic patterns changed under the improved method of control. The system covered the core area of the city, and a number of journey time measurements indicated that there had been an overall improvement of approximately 25 percent. A com-

TABLE 2 An Evaluation of Traffic Restraint Methods (2)

Issue, Restraint Method	Can Restraint Be Applied Only to Traffic Causing Congestion?			How Difficult to Implement?				How Difficult to Enforce?		
	Can Be Restricted to Area of Congestion?	Can Be Restricted to Time of Congestion?	Level of Restraint Can Easily be Adjusted?	Can Be Implemented Quickly?	Requires New Administration?	Requires New Laws?	Would Need Better Bus Service?	Special Enforcement Required?	Fraud Possibilities (other than officer corruption)	Would It Raise Revenue?
Fuel rationing	No	No	Yes	Yes, say 6 months	Yes	Yes, straightforward	Yes, whole of Bangkok	Yes, at fuel outlets	Yes, fuel at black-market	No
Odd/even number plate	Yes	Yes	No, only in large increments	Yes, say 6 months	No	Yes, straightforward	Yes, to congested area	Yes, on-street	Yes, duplicate registration plates	No
Car-less day	Difficult	Yes	No, only in large increments	Yes, say 6 months	Yes, but may be part of vehicle registration procedure	Yes, straightforward	Yes, whole of Bangkok	Yes, on-street	Yes, duplicate windscreen licenses	No
Increase fuel/vehicle costs	No	No	Yes	Yes, immediately	No	No	Yes, whole of Bangkok	No	No	Yes
Area road pricing	Yes	Yes	Yes	Yes, say 12 months	Yes	Yes, fairly straightforward	Yes, to congested area	Yes, on-street	Yes, duplicate licenses	Yes
Cordon pricing	Yes	Yes	Yes	Yes, say 12 months	Yes	Yes, fairly straightforward	Yes, to congested area	Yes, on-street	Yes, duplicate licenses	Yes
Parking controls	Yes	Yes	No	No	Yes	Yes, complex	Yes, to congested area	Yes, on-street and on private property	No	Yes
Strict vehicle tests	No	No	No	No	Yes	No	Yes, whole of Bankok	Yes, on-street	No	No

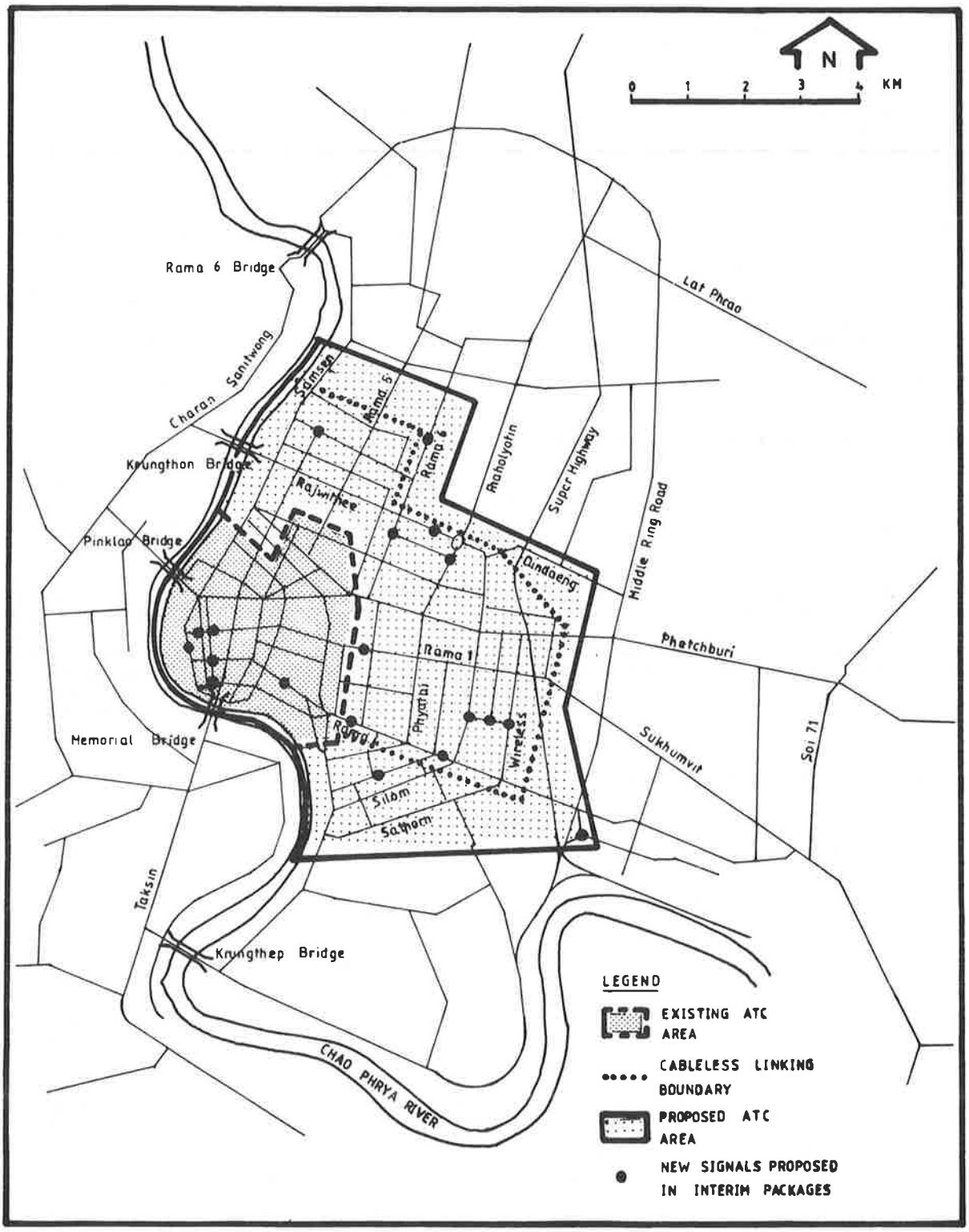

FIGURE 1 Bangkok–area traffic signal control.

prehensive research study was conducted by the Asian Institute of Technology (3) to determine the effects of the ATC system. The study showed that a significant change occurred in the speed of cars before and after the introduction of the system (Table 3). The bus travel times were also substantially reduced. The overall system is estimated to save annual fuel consumption between two and four times its capital cost (4).

A second part of the TESL contract was the supply and installation of 44 GEC Type 25 controllers to create a network of coordinated signals that included the major arterial routes from the north and east areas of the city. The cableless linked system

TABLE 3 ATC System—Changes in System Speed, Cars (3)

Time Period	System Speed (km/hr)			Number of Road Sections in System
	Before	After	Change (%)	
7:00 a.m.-9:00 a.m.	14.9	15.5	4.0	20
9:00 a.m.-4:00 p.m.	12.8	16.6	29.7	25
4:00 p.m.-6:00 p.m.	12.5	17.5	40.0	18
6:00 p.m.-8:00 p.m.	18.7	24.5	31.0	16

Note: System speed is defined as traffic demand (vehicle kms) divided by time spent in the system (vehicle hours), for each time period.

was completed on time and began operating in May 1979. However, traffic police continued to operate the controllers manually for long periods, especially along the heavily congested corridors of Rama 4, Rama 1, Phetchburi, Phayathai, and Rajrarop, and only limited use was made of the system's coordination capability.

In January 1980, systematic testing of part of the area (Rama 1) was begun in an attempt to fully commission the signal network and to demonstrate its capability to police. The signal timings were carefully adjusted to 150-sec cycle time, and the police allowed the system to operate automatically for the "after" survey. Extensive congestion resulted and, after 2 days, the trial was abandoned. A study of the results of this trial indicated that a cycle time longer than 150 sec was likely to prove beneficial, but probably not as beneficial as the 250- to 300-sec cycle times that are currently used by the police over most of the city.

To maintain the program of improvements and modifications of Bangkok signals and to supply urgently required new installations following road improvements by the BMA, additional contracts for installations have been awarded by local competitive bidding to two other international traffic signal companies, thus broadening the range of products available. The success of the central ATC has illustrated the potential benefits to be gained by the enhancement of the system to provide control over a city-wide area. Bangkok currently has approximately 230 signal installations and this number is expected to reach 300 in the near future. In the 10-yr lifetime of an ATC system, this number could easily rise to 500.

Specifications and contract documents were completed in mid-1984 for a modern area traffic control system that covers all signal installations within the Bangkok metropolitan area. The system will be based on the use of fixed time plans. Traffic-responsive systems are not appropriate because of (a) the large number and high level of maintenance required for the detectors, and (b) the consistently high volumes of daily traffic.

All signal controllers in Bangkok will either be replaced or modified to provide down-line loading of plans, timetables, and system time. All signal heads and cables will be refurbished or replaced to ensure that each junction is consistently equipped to the highest modern standards. Because down-line loading is incorporated, a dual computer system is not considered necessary, but a separate Traffic Engineering Computer System to run TRANSYT and various off-line traffic engineering software has been specified. The system will also include some 50 flow-occupancy detectors and a 15-camera closed-circuit television system.

The prequalification of suppliers was completed in late 1983, and it is anticipated that implementation of this system will commence in early 1985, after having been procured through international competitive bidding. The initial city center ATC scheme proved to be the nucleus about which area traffic control expertise could be developed, and now a comprehensive system with adequate power is about to be implemented.

BUS PRIORITIES

Bangkok now has the most extensive system of bus lanes of any city in Southeast Asia (5). Although the city has had contra-flow bus lanes in operation for some years, it was not until April 1979 that the traffic law was modified to enable the practical implementation of with-flow bus lanes, for which signing and road-marking standards were approved in April 1980. During 1979 and early 1980, great emphasis at the administrative level was placed on the conservation of energy in order to reduce fuel consumption for buses.

The government directed the OPP to implement extensive bus lanes. The OCMRT carried out the design and supervision of implementation of approximately 100 km of peak-period with-flow bus lanes on major streets in Bangkok in May 1980. The period between the government directive and the date of enforcement of the measures was only 3 weeks. The routes are shown in Figure 2.

The bus lanes have a number of unusual features and their implementation was specially studied by the Asian Institute of Technology and the Transport and Road Research Laboratory (TRRL). (See Table 4.) One uncommon feature of the Bangkok bus lanes is their length and extent. They operate on most of the major radial roads and on several cross routes and city center streets; for example, the bus lane on Sukhumvit Road is about 12 km long. The bus lanes essentially provide a reserved track for buses in contrast with bus lanes elsewhere that are shorter and are commonly a method of simply jumping localized traffic queues. Bus flows in the bus lanes are very high with nearly 200 buses per hour in Charoen Krung and 250 buses per hour on Phaholyothin Road, which rises to nearly 300 buses per hour and 400 buses per hour, respectively, when minibuses are included. In double bus lanes, over 450 buses per hour are normal. All buses operate on scheduled stopping services.

Although bus flows remained high, their stop times were very short (about 13 sec) and, where problems occurred, elements of comprehensive route improvement schemes were introduced, such as bus bays, central islands, junction improvements, and so forth. The law and road markings permit traffic to and from sois (local streets) to cross bus lanes at right angles. Although there is some danger in the maneuvers, the procedure has been proved to be workable, and only minor supervision is required by the police during peak periods.

Minibus operators were given the opportunity to register with the Bangkok Mass Transit Authority (BMTA) and thus, to legally use the bus lane facilities. Approximately 70 percent of the operators took advantage of this opportunity. The minibuses in the city contribute a significant amount to public transport, as occurs elsewhere in Southeast Asia. Travel time by car and bus was reduced after the introduction of the bus lanes. The initial bus-lane regulations did not permit buses to leave lanes, but these regulations were subsequently relaxed without significant loss of journey speed, although nearly one-half of the buses were running outside the bus lanes.

In February 1984, a major one-way traffic flow system was introduced in the congested central area of the city. As part of this system, an extensive

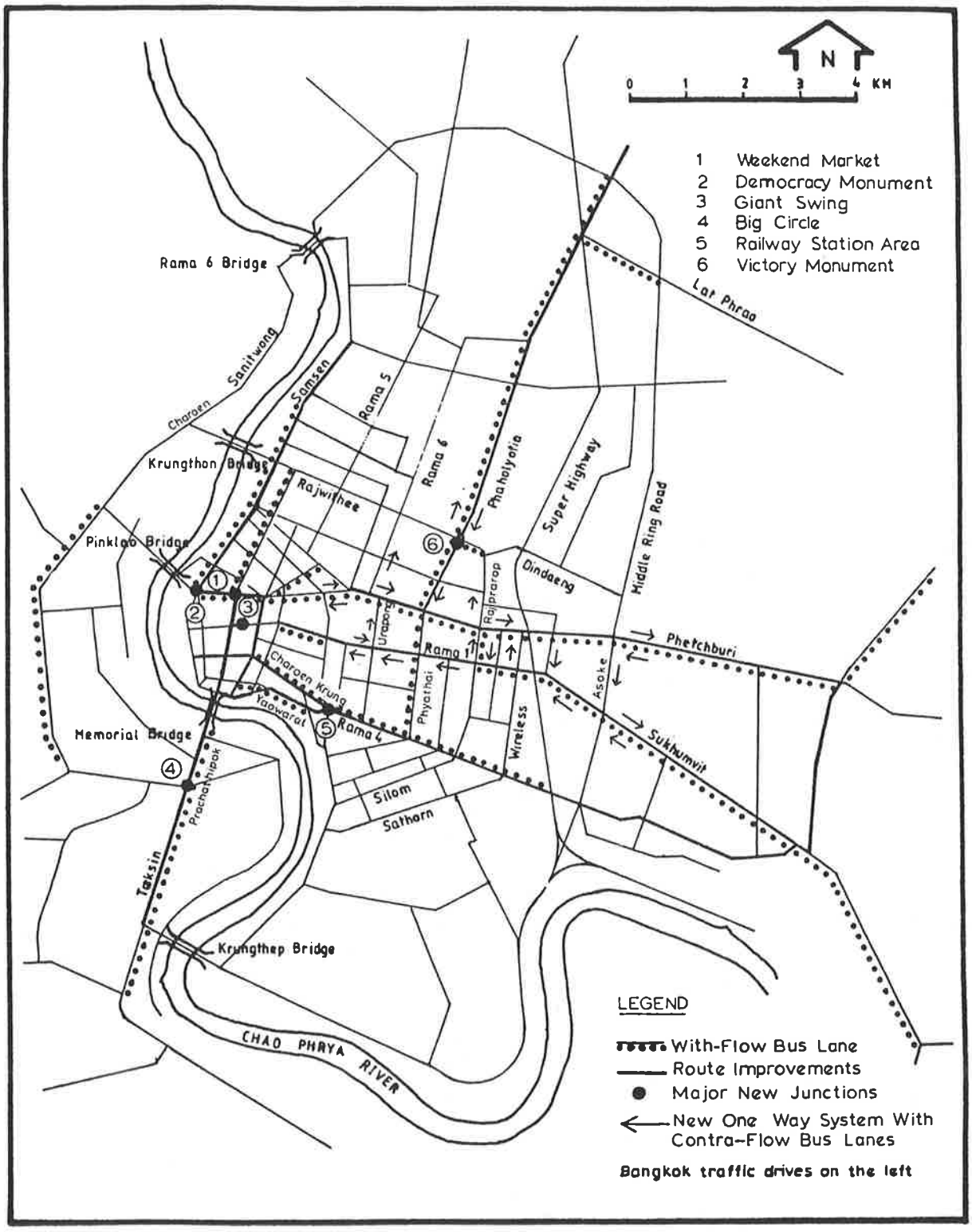

FIGURE 2 Bangkok—traffic management schemes.

network of contra-flow bus lanes was introduced to enable buses to maintain their routes. In addition, the implementation of with-flow bus lanes early in the project resulted in a gain of considerable experience in design, operation, and enforcement measures for bus priority schemes. This is now being applied effectively to contra-flow bus lanes as well. Bangkok, therefore, can now boast of having one of the largest bus priority networks in the world and can provide guidance for other areas of the world in terms of bus operations, enforcement, and capacities.

ROUTE IMPROVEMENTS

In the late 1970s, the standards of traffic management facilities such as street signing, marking, and

TABLE 4 Bus Travel Times Before and After Installation of With-Flow Bus Lanes *(6)*

Bus Lane Section	Length (km)	Mean Travel Time (min)				Mean Speed (km/hr)	
		Before	After	Difference	Change (%)	Before	After
Sukhumvit Road							
a.m. westbound	4.85	15.33	13.55	−1.78	−12	19.0	21.5
p.m. eastbound	4.85	14.90	14.74	−0.16	−1	19.5	19.7
Phaholyothin Road							
a.m. southbound	2.50	5.36	4.87	−0.49	−9	28.0	30.8
p.m. northbound	2.50	7.45	5.47	−1.98	−27	20.1	27.4
Yaowarat Road							
a.m. westbound	2.13	8.33	8.11	−0.22	−3	15.3	15.8
Charoen Krung							
p.m. eastbound	1.09	6.28	5.81	−0.47	−7	10.4	11.3

so forth, were generally not sufficient to undertake improvements separately and, therefore, a comprehensive approach to route improvements was adopted to improve street capacity and driver behavior and to make traffic regulations as self-enforcing as possible. Comprehensive route improvement schemes were, therefore, designed along main roads to be implemented on a staged basis. They would relieve key points of congestion, improve road safety, and enhance bus operations. Many schemes have now been completed, such as Rama 1, Rama 4, Phayathai, and Prachathipok. Other schemes are ready for implementation and further schemes are under consideration. The completed schemes serve as demonstrations of good traffic management practice and standards, and this type of work will be continued on new and existing roads.

Major junction improvement schemes are also planned at locations where the problems of private vehicles, buses, pedestrians, and the environment interact. The improvement of the Weekend Market area, Democracy Monument, Giant Swing, Big Circle, and the railway station area are now complete.

A major one-way traffic flow system in the central area of Bangkok was introduced by the Metropolitan Police Bureau on an experimental basis in February 1984. The system underwent some modification during the initial period of experimentation and in late February was declared permanent.

The permanent system involves some 25 km of major highway within the area enclosed by Dindaeng-Victory Monument in the north, Rama 1 Road Sukhumvit Road in the south, Soi Asoke in the east and Rama 6-Urapong in the west. The system affects and has required modifications to some 30 major intersections. Most of the intersection modifications that have been undertaken as part of the experiment were of a somewhat temporary nature. Redundant signals have sometimes been left in place, road markings have been temporarily painted out, and channelization adjustments have involved removal but not reinstatement in more appropriate locations. Many problems remain at intersections and along the links. These problems involve safety and capacity impedance for vehicles and pedestrians, such as

1. Pedestrians who cross in safety both at intersections and midlink.
2. Consistent and safe control of intersections.
3. Bus flow within the contra-flow and with-flow bus lanes and the effect of these on safety for other road users.
4. Bus stop operation, capacity, and location, which sometimes affect upstream intersection operation and link capacity.
5. Problems of taxi and samlor (a 3-wheeled motorized vehicle with a driver and 2 or 3 passengers) stopping.
6. Driver confusion in terms of lane use, merging and diverging.
7. Police control and enforcement.

The introduction of the one-way traffic system means that considerable change must be made to improve its efficiency and modify some of the comprehensive route improvements. Nevertheless, the lessons learned in how well traffic management design can improve safety, capacity, and driver behavior have not been forgotten. Route improvements are under design for roads within and without the one-way system. The early schemes provided the training ground for designers, and this experience has enabled them to quickly adapt schemes to accommodate major traffic circulation changes in the city. The route improvement schemes have thus proved to be beneficial, low cost, and most important, amenable to rapid major change.

TRAFFIC LAW ENFORCEMENT

Traffic violations play a significant role in obstructing the traffic flow in Bangkok. The most common offenses are illegal parking, jumping the red traffic light, and illegal use of bus lanes. Drivers in Bangkok are currently fined only if they are stopped by the police immediately after committing an offense. On average, 50,000 tickets for traffic offenses are issued monthly and, on average, 85 percent of the offenders fail to report to the police. In 1979, of those offenders who were processed, less than 1 percent were only cautioned, the remaining 99 percent paid a fine of some type.

Much of the traffic policing effort is spent on manual control of traffic signals but, apart from a relatively small number of key intersections, this practice could be eliminated. The day-to-day control of the intersections could be left to intermittent control by mobile police units. This, of course, would require an increased use of radio-controlled solo motorcycle patrolmen who are well-enough trained in modern traffic-control techniques to be able to take over the signals for short periods of time at peak periods. Such a system of traffic police control must be introduced in stages, starting from a small, selected central area and expanding outwards. It is essential that this system be in operation by the time an expanded system of area traffic control is introduced in 1986 and, accordingly, appropriate training under the project has now begun.

Traffic policing clearly must be coordinated with traffic management and control improvements that have been or will be implemented. The goals of any police traffic department should be to (a) ensure the free flow of traffic, (b) ensure the safe move-

ment of traffic, and (c) enforce the traffic law. These goals cannot be considered in isolation but are interdependent. The objectives of the police training will incorporate all three elements.

The situation in Bangkok is such that the police training program should be accompanied and followed by changes in the organizational and operational structure to obtain the best results. The present organization of the police traffic effort, however, creates two problems: (a) the number of mobile units is very small--there are only between 40 and 50 men on cars and motorcycles at any one time; and (b) the men employed on foot control at junctions are in a separate command structure from the traffic division. Their efforts are only coordinated at the deputy commissioner level at police headquarters. A more logical organization arrangement would be for the commander of the traffic division to have overall responsibility for all traffic policing.

SUMMARY OF PROJECT ACHIEVEMENT

Since its inception in 1978, the BTMP has achieved much. An initial city center area traffic-control scheme, approximately 120 km of bus lane, 25 km of one-way street, 4 route improvement schemes, and 4 major junction improvements are some of its directly visible successes. Its most outstanding achievement by far has been the development of a high level of traffic signal and traffic management design and implementation expertise within the OCMRT. This is now reflected in the ongoing design work for further measures.

Implementation of enhancements to all the previously mentioned pilot projects is now planned during the remainder of the project, and these enhancements will prove effective in containing the level of traffic congestion. It is expected that the roles of the OCMRT (planning), BMA (design-implementation), and the Traffic Police Division (enforcement) will be coordinated and enhanced as a result of continued appropriate training provided to each organization under the project.

The BTMP can be viewed as a successful project of traffic management, control, and training and is demonstrating its flexibility by remaining appropriate to a rapidly growing and changing city over almost a decade.

The expertise of the OCMRT staff is now demonstratively high and that of the BMA staff is being enhanced to meet the imminent requirements for new and wide area ATC system operation. Improvements in traffic police enforcement is now to be emphasized through training under the project.

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