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TRANSPORT GROWTH IN BANGKOK: ENERGY, ENVIRONMENT, AND TRAFFIC CONGESTION

Workshop Proceedings

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Workshop Proceedings

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Preface and Acknowledgments

To minimize the negative impacts of the conventional path to transport planning and investment -- a path which emphasizes supply-side options such as investment in roads and highways as opposed to potentially less expensive demand-side options such as investment in mass transit infrastructure and mass transit-oriented land use -- industrializing countries such as Thailand, and megacities such as Bangkok, require new solutions. Needed are solutions that simultaneously enable them to meet transport needs and address energy, environmental, and economic constraints. To better assess the links between transport sector growth and a decline in air quality, increases in congestion and energy consumption, the International Institute for Energy Conservation (IIEC) undertook a project to study Bangkok (and three other Asian cities) to identify opportunities for change.

To begin working with Thai transport planners, policymakers, and the public to help define a new path for identifying and implementing solutions suitable for their city, IIEC undertook the analysis of Bangkok's transport system with a Thai research team in order to fully understand the obstacles encountered in transport improvement projects. The research began in the fall of 1990 and ended with the report Assessment of Transportation Growth in Asia and Its Effects on Energy Use, The Environment, and Traffic Congestion: Case Study of Bangkok, Thailand.

The report proposes a new approach to transport planning for Bangkok that integrates consideration of ecological, social, and financial viability in the process of making decisions regarding managing existing infrastructure and investments in new infrastructure.

As a follow up to the report, IIEC's Asia Regional Office in Bangkok conducted the workshop Transport Growth in Bangkok: Energy, Environment, and Traffic Congestion in association with four Thai partners: the Office for the Commission on Road Traffic, Chulalongkorn University, the National Energy Policy Office of Thailand, and the Thailand Environmental Institute. The purpose of the workshop was to engage and contribute to discussion among policymakers, city planners, non-governmental organizations (NGOs), the private sector, and international financial institutions of the feasibility of a more integrated approach to address air quality and traffic congestion problems for Bangkok.

The workshop was conducted on the first and second days of November, 1994 and brought together over forty Thai participants with an international panel of transport experts who exchanged their expertise and insights with those of the participants. They discussed the potential for Bangkok to integrate such technologies as alternative fuel vehicles and alternative fuels with a comprehensive range of ways to travel such as mass transit, water transport, walking, and cycling. Land use consideration were repeatedly highlighted over the course of the two-day workshop as a means of encouraging mass transit and discouraging excessive trip making by private vehicle. Perhaps most importantly, however, were the discussions regarding Bangkok's institutional decisionmaking structure and the opportunities for more effective intergovernmental cooperation and collaboration.

The workshop and these proceedings would not have been possible without the financial support of our funders. Direct support for these proceedings comes from the Canadian International Development Agency, the U.S. Environmental Protection Agency, the U.S. Department of Energy, the United Nations Development Program, and the World Bank. We also graciously thank our Thai partners who worked in association with us to conduct the workshop. And finally, special word of thanks to IIEC staff for all their support and patience. Asia Regional staff Terry Oliver, Uaypom Satitpanyapan, and Sa-nguansak Ka-uraphan, gave new meaning to the definition of teamwork. Without their help, the workshop could not have been conducted, and these proceedings could not have been produced. In the Washington, D.C. office Danielle Lucid, Martha Asfaw, and Casey McCullough were key staff in developing the workshop materials, and coordinating complicated logistics. Their commitment and patience throughout the project is greatly appreciated by all.

We hope that this set of proceedings, as well as IIEC's other transport reports, are read with interest by policymakers, transport and land use planners, non-governmental organizations, members of the private sector, and international financial institutions advocating change in conventional transport system management and development. The papers contained within, and the participants' observations and recommendations at the end, are intended to provoke further thought and experimentation with integrating a range of policy measures and technological applications to achieve more environmentally, financially, and socially sustainable transport systems -- not just in Bangkok but wherever needed in cities around the world.

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Introduction

Bangkok, the capital of Thailand, is a physically and economically complex, and vibrant city. It is also a city with a complicated transport system -- a city whose transport-related air quality and congestion problems are notorious throughout the world. With daily traffic congestion averaging 16 hours, the air quality is such that to breathe street level pollution for 8 eight hours is roughly equivalent to smoking nine cigarettes per day. Estimates suggest that idling traffic costs up to 40 billion baht ($1.6 billion) annually. Energy use within the transport sector is on a steady rise with estimates that by the year 2006 the amount of energy use will increase two and one half times. There are also severe health impacts that have begun to effect many of Bangkok's nine million residents -- young children and the elderly being particularly vulnerable.

The good news is that Bangkok's air quality and congestion problems are far from hopeless. Great potential exists for Bangkok to remedy its transport-related problems. The city has many of the necessary characteristics that would allow it to have a system of transport that would be the envy of cities around the world. For example, its high density level makes the city a prime candidate for an efficient system of mass transit. The multitude and close proximity of shops, street vendors, restaurants, and residential areas give the city a vibrant street life that is highly conducive to walking and cycling. Technical knowledge and capacity to devise and implement innovative policies and projects to address air quality and congestion problems is plentiful. There is also consensus among Bangkokians -- creating a firm basis to increase the political will of policymakers to effect change -- that something needs to be done immediately to clear the air and the roads. The problem, however, is that despite the factors in favor of remedying Bangkok's transport-related problems, little has been done.

Instead, countless studies have been conducted that offer conclusions about specific policies that should be implemented and technologies to be applied, but few of these recommendations have been undertaken and successfully implemented. In the meantime the financial, environmental, and social costs to the people, the city, and the country continue to mount. The tenacity of Bangkok's air quality and traffic problems, despite countless efforts to resolve them by Thai planners and decisionmakers, suggests that the solutions needed are far more complex than a mere formation of policy or application of technology.

Defining a New Path for Identifying Solutions and Implementing Them in Bangkok

The additional layer of complexity in successfully addressing Bangkok's transport-related problems is the way in which problems are defined, the types of solutions developed, and the institutional mechanisms by which investment decisions are made and implemented. For example, some policymakers, planners, and financiers define Bangkok's congestion problem as insufficient roadspace for travel by private vehicle. Thus, they propose increasing the amount of per capita kilometers of roadway, and therefore focus investment in road and highway construction. This focus continues despite mounting evidence and increasing documentation that suggests an exclusive focus on road and highway investment exacerbates -- and thereby complicates -- the congestion problem.

A problem for Bangkok (and many other cities around the world) is that latent demand for road space far exceeds the city's physical and financial capacity to build its way out of congestion. The problem is perhaps better defined as insufficient, viable travel alternatives besides private vehicles for Bangkokians, as well as insufficient mechanisms to manage demand for travel and roadspace to help clear the air and the roads.

A definition of the problem that is as comprehensive and accurate as possible is the first step in unraveling the layers of complexity associated with a difficult situation. One of the purposes of the workshop was to begin unraveling the complexities surrounding the nature of Bangkok's transport system. Another purpose was to engage policymakers, city planners, non-governmental organizations, the private sector, and international financial institutions in a non-political, non-binding discussion of the feasibility of a more integrated approach to address air quality and traffic congestion problems for Bangkok.

The workshop brought together an international panel of experts in the field of transport system sustainability, and was structured to allow for smaller group discussion led by members of the panel. During the small group discussion, approximately 40 participants representing local government, the private sector, NGO's, and international financial institutions, and concerned citizens worked directly with the panelist. In the small group sessions, which included six to eight participants and at least one panelist as facilitator, some of the barriers and opportunities for government to implement different policies measures and technological solutions were identified. In the last small group session on the second day, the participants and the panelists listed recommendations for the next steps to moving toward a more integrated approach to the management and development of Bangkok's transport system.

The discussions focused on how to integrate a range of policy measures and technological applications such as alternative fuel vehicles and fuels to water transport, cycling, and land use policy. As noted by one of the participants from the Office of the Commission for the Management of Road Traffic, a wide variety of policy measures and technological solutions have already been proposed, and the problem is how to see these proposals through to implementation. Of particular relevance to each small group discussion was the issue of building political will to implement change, and identified were specific mechanisms to foster more effective intergovernmental cooperation and collaboration.

Organization of Papers

The papers contained the following Workshop Proceedings were drawn from the workshop presentations. The purpose of the proceedings is to make available the presentations of the workshop's international panel of experts, and the observations and recommendations that resulted from the small group sessions. The papers and the recommendations resulting from the workshop are intended to provoke further thought and experimentation with building the political will among Bangkok's policymakers to effect change, and how to integrate a range of transport policy measures and technological applications that foster a less polluting, more energy-efficient, and less congested system of transport — not just in Bangkok but wherever needed. The proceedings are also intended to help move Bangkok one step closer -- in a process that will require many subsequent and difficult steps -- to build political will and implement a more integrated approach to transport system management and development.

The papers are arranged as follows:

1. Background and Context. The first two papers set the context of the current state of Bangkok's transport system:

   - The first paper by Chamlong Poboon, Jeff Kenworthy, and Paul Barter of Murdoch University, Perth Australia sets the historical stage for the forces and circumstances that shaped the development of Bangkok's present transport system. The paper also gives form to potential solutions.

- The next paper by Setty Pendakur and Madhav Badami of the University of British Columbia compares and contrasts the plight of two megacities: Bangkok and Mexico City. The paper demonstrates that Bangkok is by no means the only city with severe transport-related problems, and that many of the world's present and future megacities may be headed toward a similar fate as these two cities.

2. Addressing Air Quality. The next two papers specifically discuss Bangkok's air quality, and offer an evaluation of the likely outcome of different measures to address the problem:

   - The first paper by Sangsant Panich of Chulalongkorn University describes the status of Bangkok's air quality as a result of emissions from using gasoline, diesel fuel and LPG fuel vehicles. He also discusses some of the local and global health and climatic implications of unmitigated pollution.

   - The second paper evaluates the impact of existing and planned transport management measures on air pollution projected by the year 2000. The paper by Naree Boontherawara of the Thailand Environmental Institute; and Sangsant Panich and Kunchit Phiu-Nual of Chulalongkorn University is based on a study of three mathematical models -- a transport model, an emission factor model, and a dispersion model.

3. Traffic Congestion. Kumroplok Suraswadi, the Office of the Commission for the Management of Road Traffic (OCMRT), gave a presentation based on the Mass Rapid Transit Systems Master Plan for Bangkok. The complete Master Plan document details new OCMRT traffic management projects currently in the pipeline to address congestion -- and by default air quality -- in the city. The document also discusses

socio-economic benefits from investment in mass transit, environmental considerations, and the economic and financial criterion used for analysis to guide decisionmaking.

4. Transport System and Energy Efficiency. Terry Kraft-Oliver, the International Institute for Energy Conservation (IIEC) located in Bangkok, puts into context the reduction in energy use possible with an approach to transport system investment that integrates a variety of more energy-efficient alternatives, including those options that reduce the demand for travel. This paper, based on Transport Growth in Bangkok: Energy, Environment, and Traffic Congestion, notes that technological applications alone will not be sufficient to address air quality and congestion problems. Alternatively, what is needed is a full array of options, particularly appropriate land use policies, as well as responsive institutional structures.

5. Regional Perspectives. The next two papers contribute to understanding of other transport systems in the region. The first paper in this section by Primitivo Cal, Undersecretary of Transportation for the Philippines is a review of the Transport and Traffic Management Plan (1993-1998) for Metro Manila. It is the most recent urban transport strategy to deal with the projected growth of Metro Manila. The second paper is an excerpt of the book A Developmental Approach to Urban Transport Planning: An Indonesian Illustration by Harry Dimitriou of the University of Hong Kong. The full excerpt is included in the Appendix.

6. Implementing Solutions & Lesson Learned. The following three papers focus on existing and developing solutions to air quality, traffic congestion, and overall system and energy efficiency concerns:

- The first paper, by Yorphol Tanaboriboon of the Asian Institute of Technology, highlights some of the successful practices, as well as unsuccessful attempts, of demand management techniques applied in Singapore and Bangkok.
- The second paper offers insights into more effective implementation based on the experience of Curitiba, Brazil. Jonas Rabinovitch of the United National Development Program, formerly with the City of Curitiba, describes not only the development of the public transport system, but also the planning process and administrative framework that was needed to make it possible.
- The third and final paper in this sector is by Samuel Seskin of the consulting firm Parsons, Brinckerhoff, Quade and Douglas, Inc. of Portland, Oregon, United States. His paper focuses on four aspects of metropolitan planning and development: the relationship between land use and travel demand, analytic tools to evaluate policy or project effectiveness, the array of approaches used by government to integrate transport and land use, and the importance of a mechanism for, and the benefits of, public participation.

BANGKOK: ANATOMY OF A TRAFFIC DISASTER

By Chamlong Poboon, Jeff Kenworthy, and Paul Barter

Introduction

Bangkok, the Thai capital of about 6 million people is now well known worldwide for its disastrous traffic problem. The issue appears regularly not only in Thai newspapers and magazines, but also in the foreign mass media. For example, an article in the Earth 2000 section of *The West Australian*, October 5,1992 entitled *'Congestion City'* commenced by depicting the intimidating impact of Bangkok traffic:

> *'The IQ of the people of Bangkok is decreasing. Traffic jams pump so much poisonous lead into the air that the average child has lost four intelligence points by the age of seven. The snarl-up is so appalling that the Thai capital's cars burn 110 million kilograms of petrol each year just waiting for the traffic lights to change. ....'*

Despite public awareness and a number of proposed measures to solve the problem, Bangkok's traffic continues to become even worse. Along some main roads during peak hour, traffic speed is almost at walking pace. Air pollution is very severe and adversely impacts the health of Bangkok residents. Energy and time loss in the idle traffic is enormous. Moreover, some international business is now leaving or avoiding Bangkok.

This paper attempts to show Bangkok's current transport and traffic situation, land use patterns and energy consumption and also to interpret them in an international perspective. It also briefly reviews the history of transport development, land use and population to show how Bangkok got to where it is today. The paper then tries to analyse the root of the present problems, and finally suggests plausible solutions to tackle the traffic chaos.

Geographic Aspects

Bangkok is located in the central part of the country along the Chao Phraya river which flows from north to south into the Gulf of Thailand. Bangkok is on an alluvial plain and the whole area is flat and low, on average about 1 metre above mean sea level. The climate is tropical with high temperature and humidity. In addition to the Chao Phraya river, which is the major river of Thailand, there are a number of canals in Bangkok, both natural and man-made, which are linked with the river. In former times the main mode of transportation in Bangkok was waterways. Not until recently has road transport become the dominant mode.

The entire area of the Bangkok Metropolis is about 1,570 square kilometres with a population of around 6 million in 1990, which is about one-tenth of Thailand's population. Bangkok is divided into 36 administrative districts under the Bangkok Metropolitan Administration. However, for planning and conceptual purposes, the city can be divided into 3 zones: the inner zone, the middle zone and the outer zone, which have areas of approximately 214, 537 and 818 square kilometres respectively. These will be used for analysis of the traffic situation later.

Brief Historical Background to Bangkok

About six hundred years ago when Ayuthya was the capital of Thailand, Bangkok was only a small fishing village located south of Ayuthya. The only way to communicate with the capital was by boat which took about four days. After the Ayuthya period was ended in 1867 by a Burmese invasion, Thonburi, on the west bank of the river became the capital of Thailand for 15 years. Then in 1782 Bangkok was established as the capital of Thailand by King Rama I, the first king of the Chakri Dynasty. His reason was that more than half of the eastern bank area was surrounded by water and although the land was low and was usually flooded almost every year, it was a lot easier to protect the capital from enemies. King Rama I named the new capital 'Krungthep Mahanakorn etc,' which means 'the Great City of Angels', but foreigners still call it Bangkok as in previous times.

Urbanisation: Population, Land Use and Transportation Development (1782-1994)

With regard to transportation features, Bangkok's urbanisation can be chronologically classified into three periods as follows:

1. The water-based transportation and walking period (1782-1867)
2. The transport modernisation period (1868-1946)
3. The period of growing automobile dependence (1947-present)

Water-Based Transportation and Walking Period (King Rama I to King Rama IV, 1782-1867)

Although the population of Bangkok at the time that it became the capital of Thailand has various estimates, the most reasonable figure for Bangkok's population in 1782 is approximately 50,000 people. By the end of the King Rama III period in 1850, the population is estimated to have doubled to 100,000 (Sternstein, 1982).

The city was originally bounded by the city wall. The area of the city was about 4 square kilometres which means the city had an average walking city density at around 125 to 250 people per hectare (Newman and Hogan, 1987). Most of the people of Bangkok dwelled along the river or canals. The residential areas were mainly close to the Grand Palace, which is the centre of the city, and were mixed with commercial areas or located very close to them (Boonnark, 1985).

Waterways and walking were the main modes of transportation and communication in Thailand for many centuries. Bangkok also originally followed this pattern, due both to its geographic factors (the river and some existing canals), and to its small area which facilitated walking. Most people in Bangkok at that time used boats as their means of conveyance. Only in the middle of the city were there small streets paved with bricks. Not until the mid 19th century in the reign of King Rama IV, were some larger roads constructed. However, despite the construction of such roads, waterways still remained the main mode of transportation and communication, and walking was still the main mode of land transportation. Motor vehicles were still unknown among Bangkokians. Furthermore, additional canals were excavated in the period to facilitate movement of the mass of people (Bhamorabutr, 1982)

The Transport Modernisation Period (King Rama V to King Rama VIII, 1868-1946)

The population of Bangkok in 1882, near the beginning of this period, was approximately 169,000, while the urbanised area was about 10 square kilometres. This gives a density of around 170 persons per hectare. From that time the population started to increase noticeably due to an increase in migrants from overseas and the countryside, coupled with a decline in the mortality rate (Sternstein, 1982).

The population started to spread out from the city wall. Residential areas also began expanding further away from the banks of the river and the canals. Later, after more roads and other land transportation routes were constructed, houses and shops began to locate along these high accessibility corridors (Saksri et al, 1989) Subsequently, in 1910 the population of Bangkok had grown to slightly over 500,000. The built-up area had expanded to about 24 square kilometres, giving a density of over 200 persons per hectare.

This period was characterised by Thailand's emergence into the world of modern transportation systems. A number of major new technologies were introduced to the country, particularly in Bangkok. Horse-drawn and then electric tramways, buses, railways, modern road building practices and motor vehicles were all introduced to Bangkok from the beginning of this period. Nevertheless, at the beginning of this period, in the reign of King Rama V, some more canals were also dug to improve communications between the city and its suburbs and surrounding towns. Most canals were maintained in good condition and continued to serve as a major mode of transportation (Bongsadadt, 1982; Saksri et al, 1989).

The second half of this period experienced an increase in land transportation, and a decline in water transportation. More roads were constructed and a more comprehensive network of buses and tramways was developed. A considerable number of people in Bangkok converted from their traditional water-based transportation to public land transportation modes, while wealthier residents and foreigners were likely to use motor cars. However, the number of motor vehicles in Bangkok was still very low (Bongsadadt, 1973; Sternstein, 1982). Despite the development of motorised land traffic in this era there were still significant constraints on the growth of Bangkok due to the low lying landscape and its importance for agriculture. Thus Bangkok expanded along well defined corridors which are very efficient for public transport but contain the seeds of Bangkok's future 'traffic disaster'.

The Period of Growing Automobile Dependence (1947-present)

This period started immediately after World War II. The Thai government under the leadership of Field Marshall Pibul Songkram (1946-1958) paid more attention to the development of Bangkok as the centre of the country. Later Field Marshall Sarit Thanarat's government (1958-1963) stressed economic development to keep pace with the world economy. The government also implemented decentralisation through remote areas development and established regional centres. State highways which linked Bangkok with other regions were constructed with American support. Nevertheless, Bangkok remained the centre of all activities thus the roads brought people and traffic to Bangkok rather than being the basis of decentralisation (Bongsadadt, 1973).

From 1947 to 1960, Bangkok's population grew at a considerable rate, approximately 7 percent annually. As a result, Bangkok added 1 million people to its population within those 13 years (the population increased from 1.2 million in 1947 to 2.2 million in 1960). This was due to urbanisation as well as a noticeable decrease in the mortality rate coupled with a high birth rate (Sternstein, 1982). After the promotion of family planning schemes in 1961, there was a noticeable decline in fertility, however, from 1960 to 1970 the population continued growing at a substantial rate, of around 5 percent annually. This was attributable to a huge migration from other towns and the countryside throughout the nation. Most of these migrants moved to Bangkok to find jobs, to do business, to study or generally to seek a better standard of living.

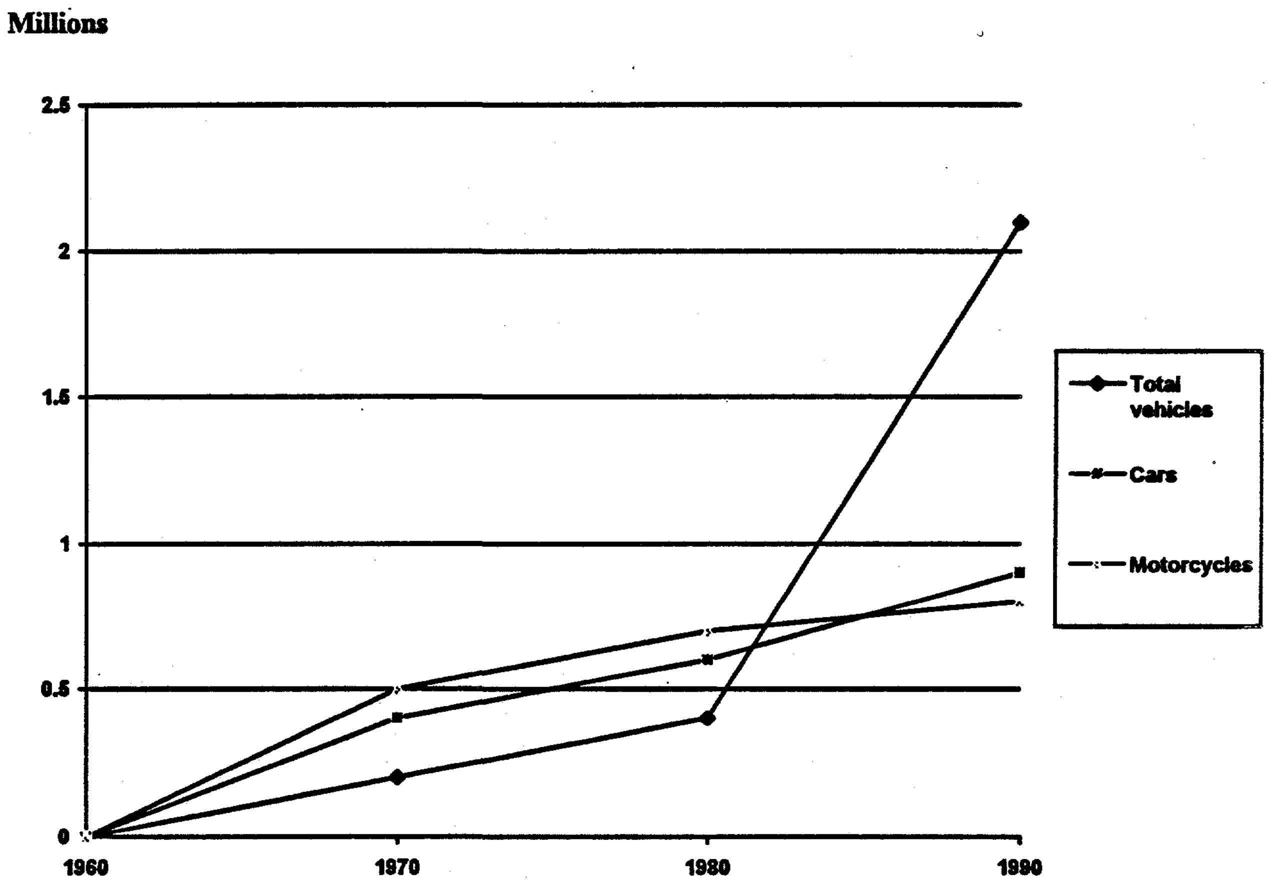
From 1960 Bangkok grew rapidly and sprawled out through its surrounding areas. Most industrial, commercial and residential development took place along the road transport corridors to ensure adequate accessibility and to avail itself of cheaper land prices in fringe areas. Later, networks of secondary roads and small lanes were built to facilitate access to land further away from the major road corridors, but without any systematic planning. This led to haphazard development and left many other parcels of land almost inaccessible (Mekvichai, 1992).

The government's urban planning and transport policy at that time attempted to develop Bangkok by imitating other developed countries which promoted road-based development. A number of canals were filled in and roads were built where they had been. Furthermore, the first Bangkok plan conducted by an American consulting firm, Litchfield Whiting Brown & Associates, called 'The Greater Bangkok Plan BE 2533 (AD 1990) and which was finished in 1960, also accentuated road-based transportation as in American cities. Although this plan and its successive plans have never been formally adopted, they had an influence on Bangkok's development. More roads have been built to cater for motor vehicles, including expressways which were intended to solve the traffic problems. Non-motorised transport, such as tricycles and hand-pulled rickshaws eventually disappeared from Bangkok roads. Trams, which had played a key role in the previous period, were considered to be obstacles to road traffic and were entirely eliminated by 1968 (The Technical Section of Thai Farmer Bank, 1992).

During this period Bangkok experienced an accelerating rate of increase in motorised vehicles. In 1947 there were only around 6,000 vehicles and only 13 year later in 1960 the figure had increased to 70,000. From this period until 1980, the figure rose steadily. In 1970 the numbers stood at 275,000 and by 1980 there were 570,000 vehicles. From 1980 onwards, vehicular numbers have soared and in 1990 the figure was nearly 4 times higher at over 2 million (Bongsadadt, 1973; Department of Land Transport, 1960,1970,1990). Bangkok has been growing towards an automobile dependent city at an alarming rate since 1980.

Bangkok's roads are dominated by cars and motorcycles as in 1990 there were about 900,000 cars and 700,000 motorcycles in the total number of 2.3 million vehicles. The number of cars and motorcycles has been soaring since 1980. In that year there were around 230,000 cars and 172,000 motorcycles in Bangkok, a decade later the numbers had amazingly increased more than four times. An estimated 600 new cars are added to Bangkok roads daily. This means that roughly an extra 3 km of bumper-to-bumper cars are added each day to Bangkok's roads which is 1,100 km per year. Considering Bangkok's road network is only 3,780 km, this means that in only less than 4 years enough cars are added to fill the entire road system with one lane of traffic. Figure 1 shows the numbers of all vehicles, cars and motorcycles in Bangkok from 1960 to 1990.

Figure 1. Number of all Vehicles, Cars and Motorcycles in Bangkok from 1960 to 1990



Source: Department of Land Transport

The marked increase in motorcycle numbers in Bangkok may be attributable to three factors. Firstly, their prices are comparatively low and affordable for many of Bangkok's households who generally have low incomes. Secondly, motorcycles can move faster than other means of transportation in the traffic jams because they can zig-zag between idled cars and buses. Thirdly, because Bangkok has sprawled out so quickly, a great number of residential areas are not yet served by any means of public transport, thus the motorcycle is the only accessible and viable alternative for these inhabitants.

In 1991 the government lifted the ban on importing fully assembled small-engine cars and dramatically reduced the import duties on small cars from around 300 percent down to 20-30 percent in order to improve the quality of local industry by allowing foreign competition. Unfortunately, as car prices decreased, they are now easier to purchase which is conducive to a further increase in the number of cars on Bangkok roads (Sayeg, 1992:p.26). In 1992 the number of cars per 1,000 inhabitants had reached 200 per 1,000 people which, although still a lot lower than American, Australian and European cities, is by far the highest among other Asian cities including richer cities like Singapore (101 per 1,000 in 1990) and Hong Kong (43 per 1,000 in 1990). In 1990 car ownership in Tokyo had reached 225 cars per 1,000 people, thus Bangkok is not far behind this wealthy city (Kenworthy et al, 1994).

Economic Perspective

Since early last decade, Thailand has experienced unprecedented economic growth. From 1980 to 1988, the country doubled its Gross Domestic Product (GDP). During the 1987-1990 period, the average rate of growth was 11.2 percent annually. The Bangkok Metropolitan Region (BMR) is the core of such growth as it has around 50 percent of the country's GDP and 77 percent of the manufacturing output (Setchell, 1992). Despite the government's attempt to decentralise the economic development to the other regions, Bangkok is likely to continue to be the dominant centre of the country's economic activities from a purely economic perspective. However, the traffic crisis described in this paper places some cloud over Bangkok's economic future when it is considered that post industrial cities are competing on the basis of attractive environments for living and working (Newman, 1994).

As a consequence of Bangkok's growth, there has been a huge immigration from the countryside, especially the Northeast, to Bangkok. The aims of the migrants are to find jobs, to study and to obtain better living. According to the 1990 census, 34.8 percent of Bangkok residents were born in other provinces, while 1.3 percent were born in foreign countries. In addition, during 1985 to 1990, more than 700,000 people or about 12 percent of Bangkok's population migrated to Bangkok (National Statistical Office, 1990).

Since Bangkok is the centre of Thailand's economic activities, about 1.8 millions jobs were concentrated in the BMA in 1990, accounting for nearly 20 percent of non-agricultural jobs in the country (Department of Labour, 1990).

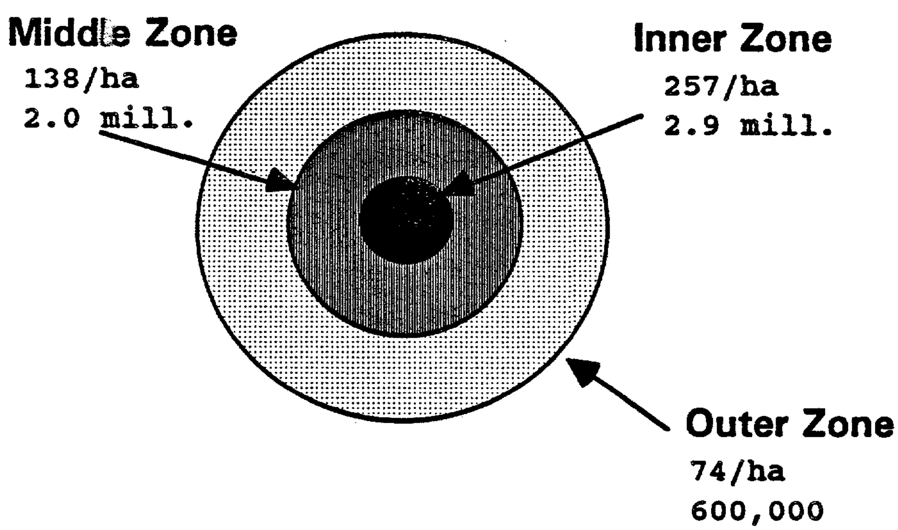
The incomes of Bangkok inhabitants are far higher than the national average. In 1988 the per capita income of Bangkok residents was around 27,000 bahts (US$ 1,100) per annum, more than twice the average income of Thais which was around 12,000 bahts (US$ 480). The per capita income of Bangkokians was markedly higher than that of the northeastern people which is only about 8,000 bahts (US$ 315) (National Statistical Office, 1989). This increasing wealth in the city compared to the region is the basis of Bangkok's growth in population and in cars. It is typical of many Asian cities and yet not all have developed the same traffic disaster. Why is Bangkok so overwhelmingly congested with traffic? And what can be learnt from its mistakes? The answer to both questions must involve a perspective on both its transport and its land use patterns.

Current Urban Structure and Land Use

The Bangkok Metropolitan Area (BMA) has a population of about 6 million people. But the entire Bangkok Metropolitan Region (BMR) which includes the 5 surrounding provinces (Nonthaburi, Pathumthani, Samut Sakhon, Samut Songkram and Nakhon Pathom), has a population of approximately 9 million. The entire area of the BMR is about 7,800 square kilometres.

According to the 1990 Population and Housing Census (National Statistical Office, 1990), the population of the Bangkok Metropolitan Area was 5,882,441, and accounted for approximately 10 percent of Thailand's population. Of these, 21.5 percent were between 0-14 years, 72.5 percent were of working age, 15-59 years, and only 6 percent were 60 years or over. A large part of within Bangkok's administrative area is still occupied by agricultural activities or is left vacant waiting for development. In 1986 only 27 percent of Bangkok's land was categorised as urbanised land (Figure 2). With regard to its development pattern, Bangkok can be conveniently categorised into three zones: the Inner Zone, including the CBD; the Middle Zone and the Outer Zone. Figure 3 shows the population and urban density of these zones.

Figure 2. Bangkok Development Zones, 1986



Note: The city is not circular, but the above diagram serves as a conceptual guide to its density profile.

Source: Calculation based on BMA 1986 data.

The Inner Zone

This area covers the old city, the new central business districts that have developed, and the rapidly growing areas. The entire area of this zone is around 166 square kilometres (16,600 ha) of which around 112 square kilometres (11,200 ha) is built-up area. The population of this zone was around 2.9 million in 1986, more than half Bangkok's entire population. It has a density of around 257 persons per hectare which is the highest among the three zones of Bangkok. For comparison, this is almost identical to central New York and central Paris (Newman and Kenworthy, 1989) and is around the historical density of the old walking city in the pre motorised period.

As the land in the city's inner area has become scarce and its price has soared and become unaffordable for low income people, a lot of new families have moved to the outer area of the BMA or its vicinity but new development has enabled density levels to be maintained.

The Middle Zone

The land use of this zone is mostly residential with a great number of housing projects along the main roads and small streets (sois), mostly developed in the motorised period. The middle zone has a total area of about 595 square kilometres (59,500 ha) of which 14,000 hectares was urbanised area. In 1986 this zone had a population of about 2 million, giving a density of around 138 persons per hectare. The density of this zone is only half of the inner zone but is still in the walking city range.

The Outer Zone

Most land in this zone is not yet urbanised. Paddy fields, fruit orchards and vegetable farms are common. The residential area has developed mainly along major roads as ribbon development. However, large areas behind the developed strips are vacant and waiting for development which will enable its owners to get more money than from farming. The entire area of this zone is around 840 square kilometres (84,000 ha) of which only 8,100 hectares or less than 10 percent has been urbanised. The population of the outer zone in 1986 was about 600,000. As a result, the density of this zone was 74 persons per hectare. This is fairly typical of new Asian city suburbs and is around 7 times the density of new suburbs in US and Australian cities and is more typical of older European transit city densities.

The structure of the city is not as depicted in figure 2- a series of rings of development - instead the Middle and Outer Zone are mainly quite distinct and dense corridors similar to European transit oriented corridors. In 1986 the BMA had a total urbanised area of approximately 336 square kilometres (33,600 ha). With the population of about 5.46 million in that year, the density of the BMA was about 160 persons per hectare. In the Asian context, Bangkok has a higher density than Manila (156) and is significantly higher than Kuala Lumpur (75), Singapore (89) and Tokyo (88), but lower than Jakarta (195), Surabaya (186) and Seoul (174), and much lower than Hong Kong (293) (Barter et al, 1994; Kenworthy et al, 1994). In a wider international perspective, Bangkok's density is high when compared to American cities, Australian cities and European cities and almost precisely the same density as the average of three wealthy Asian cities (Figure 4).

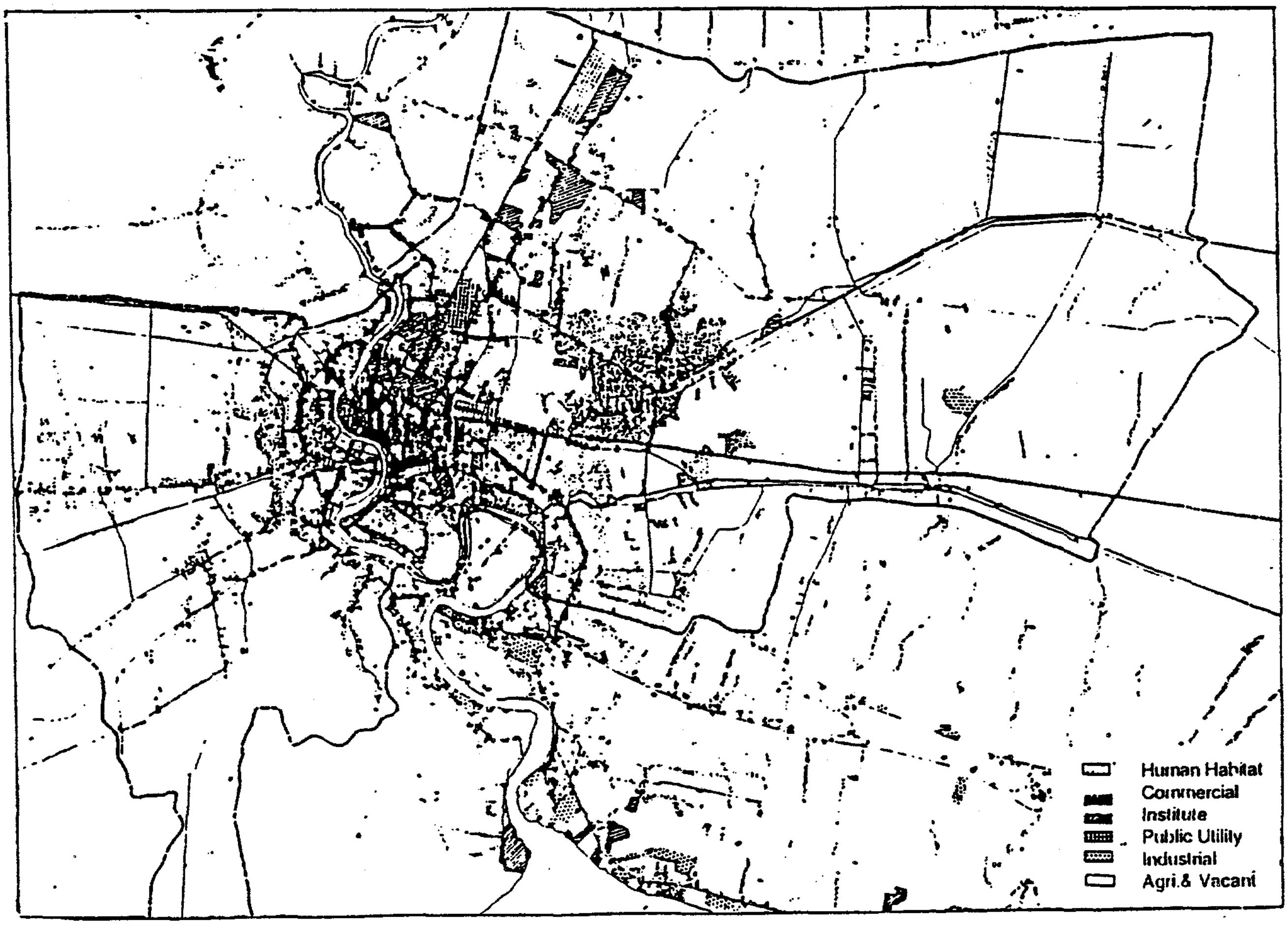
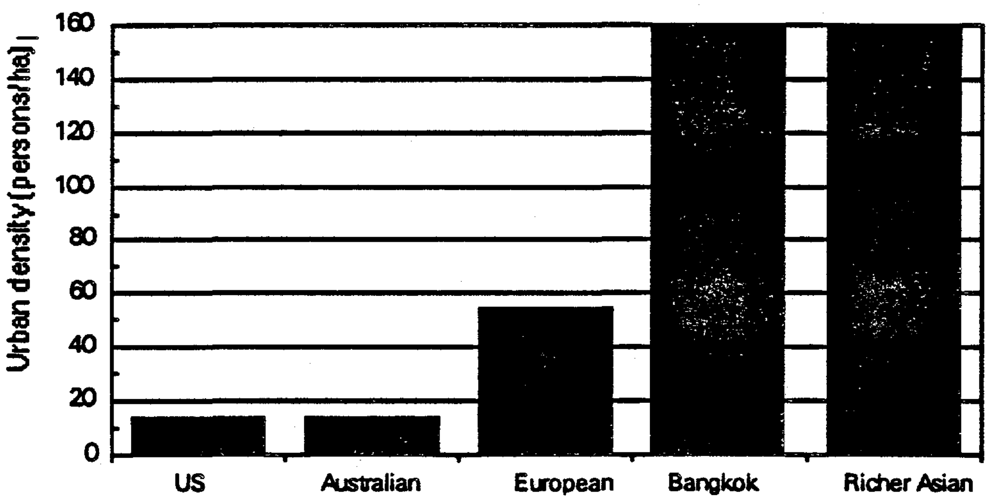


Figure 2 Bangkok's land use map, 1984
Source: Bangkok Metropolitan Administration, 1985

Figure 4. Bangkok's Urban Density Compared to Other Cities



Source: 1. Bangkok calculation based on 1986 population and land use data from BMA.
2. The other cities from Cities and Automobile Dependence by Newman and Kenworthy, 1989

Thus, in land use terms Bangkok has retained its high density urban structure despite the era of intense motorisation. It has a substantial walking city core and is surrounded by corridors of transit city urban structure. Neither are built for cars.

Transport and Infrastructure Data on Traffic Situation

Traffic in Bangkok is known worldwide for chaos. Many plans and projects have been proposed. However, the situation continues to worsen. We will now examine the data on Bangkok's traffic situation from the perspective of transport patterns and infrastructure is considered first and as there is no rail system the only data to consider are the quantity of road network and parking.

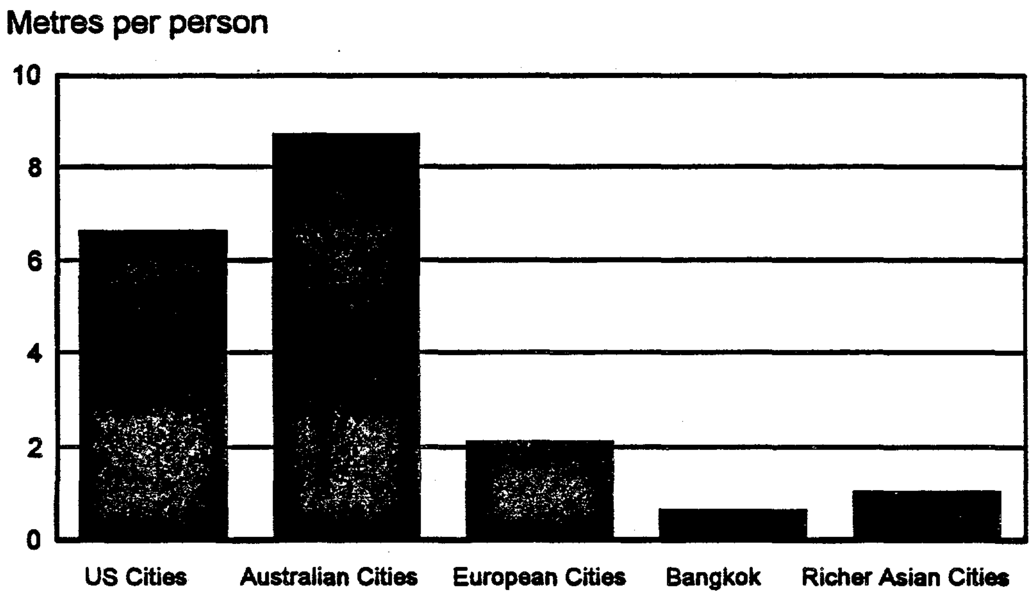
Road Network

Roads are the dominant form of transport infrastructure in Bangkok. Although the city was initially designed for waterway transport and communication, the Chao Phraya River and canals which used to be the main routes for travelling, play a very minor role. Likewise, the existing railway system which is inter-regional, has not been developed for urban commuting and contributes only a small fraction of the city's transport.

Currently, there are around 980 kilometres of major roads, comprised of primary, and secondary routes and distributors, and 2800 kilometres of small local access streets (sois) (JICA, 1990). In addition, there are 2 expressways, the first route is around 27 kilometres and the second, which has just opened for users recently after a big conflict between the constructor and the government, is about 12.4 kilometres in length.

Road space accounts for only 8 percent of the city area. In an international comparison, this proportion is very low relative to other cities like London, Paris and New York where roads occupy up to 20-25 percent of the area (TDRI, 1991). Furthermore, in terms of road length per capita, Bangkok has only 0.6 metres of road per capita, which is more than ten times lower than American and Australian cities, more than three times lower than European cities and even lower than the average for richer Asian Cities (Singapore, Tokyo and Hong Kong) (Figure 5).

Figure 5. Urban Roads Per Capita in Bangkok Compared to Other Cities



Note: 1. Bangkok 1989 data
2. Other cities 1980 data

Source: 1. Bangkok calculation based on JICA data
2. Other cities from Newman and Kenworthy, 1989

Thus the land use picture presented earlier of a walking city inner zone and a transit city middle and outer zone is borne out by the reality of very low road availability per capita as is fond in such concentrated cities. It highlights how just a small number of cars can fill the available road space very quickly.

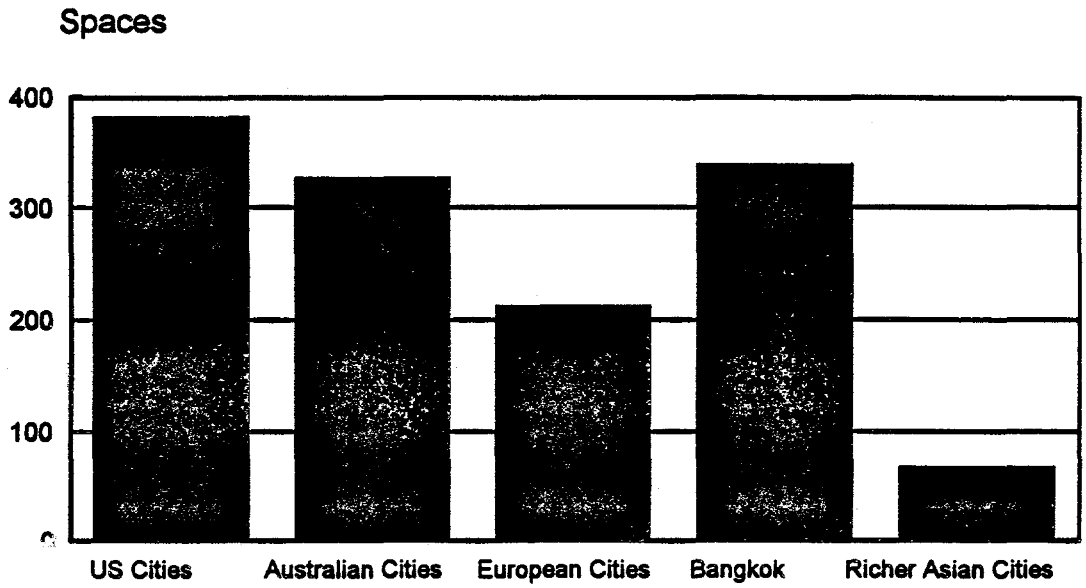
Parking

Parking is classified into on-street and off-street spaces. On-street parking is very restricted on most major roads, particularly during peak hour, but it is available on most minor roads and sois. Off-street parking is available in most big business and government offices and in large new department stores. Most older parking lots are open spaces, but due to the very high price of central land, most new parking lots are likely to be multi-storied. There is almost no control of the off-street parking.

Inside the city centre, which is surrounded by the Chao Phraya River and the Phadung Krung Kasem Canal, there are around 18,800 spaces available for off-street parking, of which 12,000 are open space and 6,800 are in buildings. In addition, the on-street parking capability of this area is about 32,000 spaces. All on-street parking is free of charge while only 20 percent of off-street parking is tolled (JICA, 1990). This is a very open and easy parking policy which encourages high car use.

The proportion of parking spaces to the number of jobs in the city centre is approximately 338 spaces per 1,000 workers. This proportion is very high compared with richer Asian cities like Singapore, Tokyo and Hong Kong which average only 67 spaces per 1,000 jobs. It is also higher than cities in developed countries like European cities and even marginally higher than the average for Australian cities. Interestingly, it is only slightly lower than American cities which are generally heavily car-oriented in their city centres (Figure 6).

Figure 6. Parking per 1,000 CBD Workers in Bangkok Compared to Other Cities



Note: 1. Bangkok 1989 data
2. Other cities 1980 data

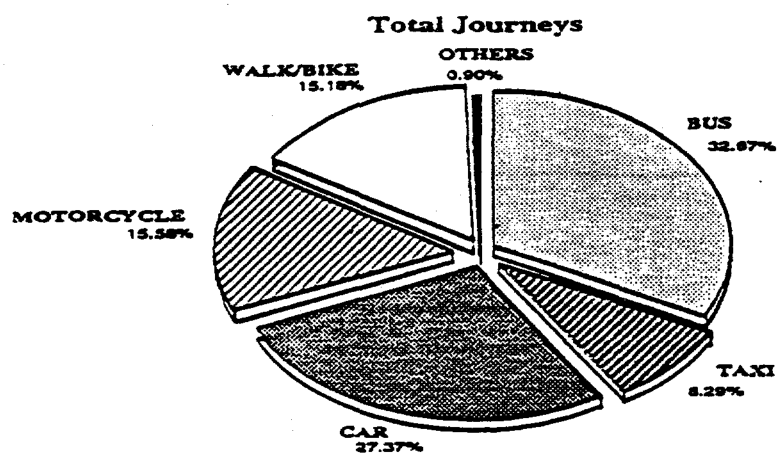
Source: 1. Bangkok calculation based on Department of Labour and JICA data
2. Other cities from Newman and Kenworthy, 1989

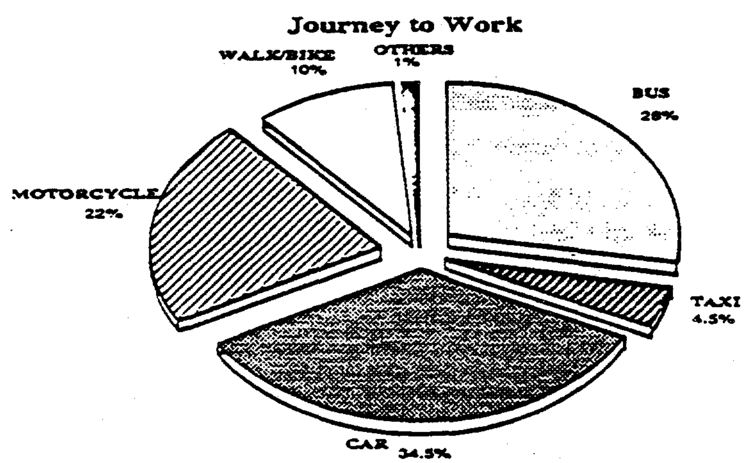
Thus despite having a city structured against car use Bangkok provides parking as though it were Houston or Detroit.

Transport Patterns

As shown in figure 7 in 1989 Bangkok residents made 15.6 million trips daily, of which 33 % were by bus, 27 % by car, 16 % by motorcycle, 8 % by taxi, only 15 % were made on foot or by bicycle. This represents an extraordinary low use of walking and bicycling for such a dense city. For example, the Tokyo metropolitan area has 45% of all daily trips on foot and bicycle (Asano, 1992).

Figure 7. Modal Split for Total Journeys and for Journey to Work in Bangkok, 1989

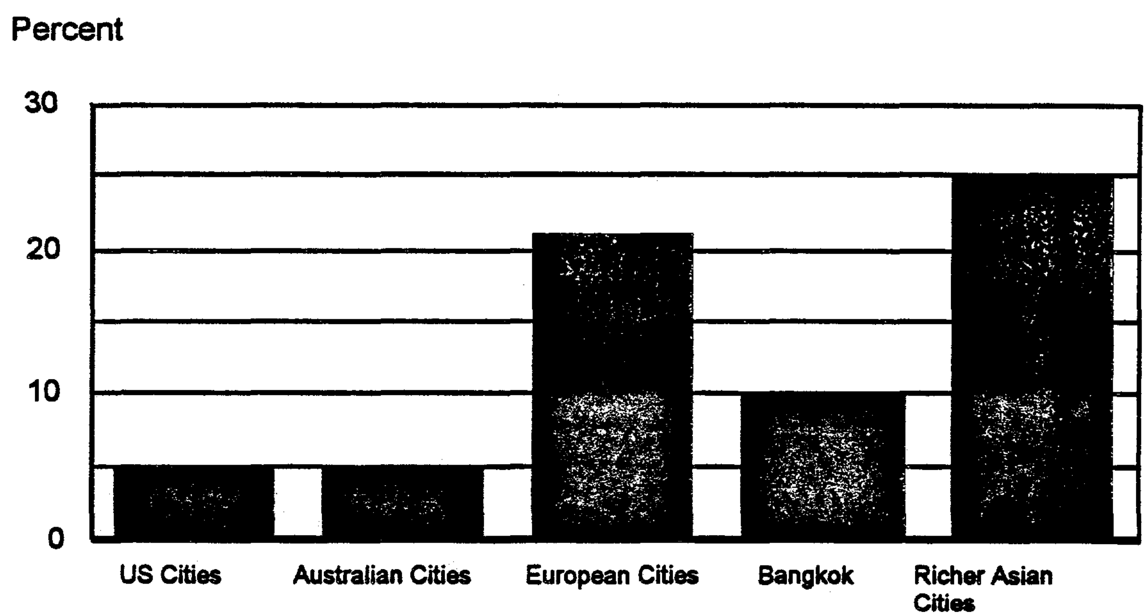




Source: JICA, 1990

Journeys to work accounted for around 20 percent of all trips or around 3 million trips daily. Bangkokians made about 90 percent of their work trips by motorised modes, only 10 percent were made on foot or by bicycle. As figure 8 shows the average for wealthy Asian cities is 25% and it is 22% in European cities. When it is considered that the inner zone of Bangkok is structured as a walking city, it is a genuine traffic diaster to find so little walking or biking. With such a small road space available being so totally dominated by cars it is little wonder that few take it upon themselves to risk the act of walking or cycling in such chaotic traffic.

Figure 8. Journey to Work by Foot and Bicycle in Bangkok Compared to Other Cities

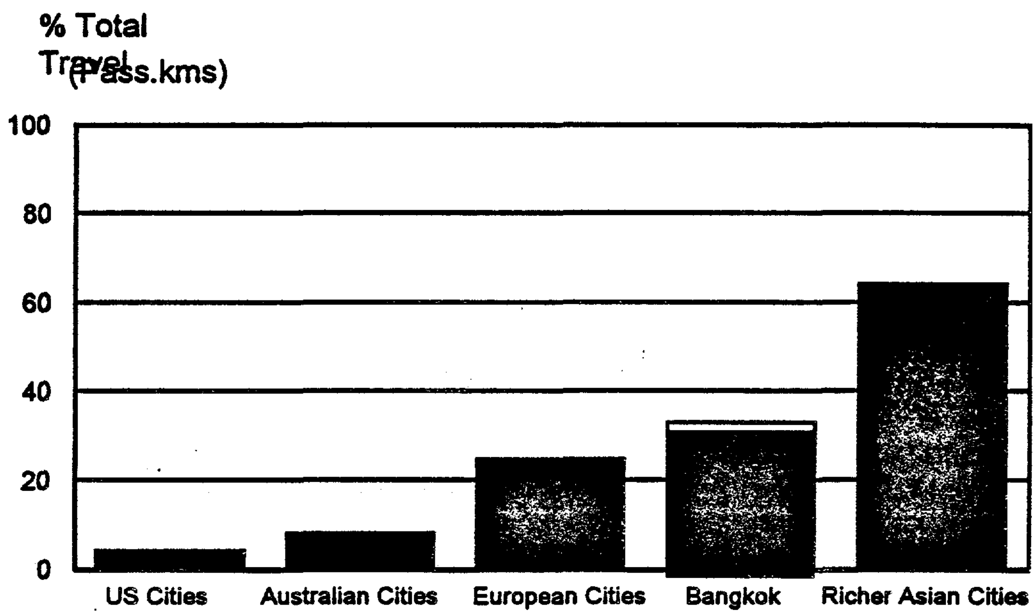


Source: 1. Bangkok calculation based on JICA data
2. Other cities from Newman and Kenworthy, 1989

Private vehicles (cars plus motorcycles) account for nearly all private transport, while public transport, only carried 28 % of work trips, which is very low compared to some other cities. For example, New York had 28 % of workers going to work on public transport in 1980, the European cities averaged 34% and Singapore, Tokyo and Hong Kong had a massive 60 % of workers on public transport (Newman and Kenworthy, 1989:p.36).

However, as figure 9 shows the percentage of total annual passenger kms on public transport reveals that Bangkok's public transport is, overall, certainly more important than in American, Australian and European cities but public transport use is about half what it is in the developed Asian cities. It is to be expected that a city structured for transit should have a relatively high use of transit and to have higher levels than in European cities is no small feat. However, the other developed Asian cities show how it is they have avoided the traffic disaster of Bangkok through such an extraordinary commitment to transit. This is something Bangkok will need to address if it is to begin solving its traffic crisis.

Figure 9. Public Transport Use in Bangkok as a Percentage of Total Passenger Travel Compared to other Cities



Note: 1. Bangkok 1989 data
2. Other cities 1980 data

Source: 1. Bangkok calculation based on BMTA and JICA data
2. Other cities from Newman and Kenworthy, 1989

Further detail is thus provided on the nature of Bangkok's public transport and where it has potential to be improved.

Public Transport

Although Bangkok was initially designed as a water-based and walking city, the present public transport is dominated by land transportation. Buses play the major role with other modes which consist of taxi, tuk-tuk (3-wheeled motorised vehicle), silor-lek (small, open van with 4 wheels) and hired motorcycle. Water transportation and railroad play a very minor role in urban passenger transportation.

Buses

Bus services are mainly operated by the state-owned enterprise, the Bangkok Metropolitan Transit Authority (BMTA). In addition, BMTA also oversees privately-owned buses and mini-buses. At present there are about 6,000 regular buses (4,800 belonging to BMTA), 700 air-conditioned buses (450 belonging to BMTA) and 2,400 mini-buses.

Regular buses are operated on 157 routes and air-conditioned buses are operated on 21 routes in the BMA and its neighbouring provinces. Minibuses are operated on 71 routes which are the same as BMTA bus routes and they also ply 128 routes along sois (BMTA, 1992). In total, buses carry around 6 million passengers daily, including around 1.1 million (18 %) by mini-buses. This accounts for around 62 percent of total public passenger demand (JICA, 1990).

Although buses in Bangkok are under the sole control of BMTA, there are a number of problems facing the authority and commuters. Financial loss has been a chronic problem for BMTA since it was established about 20 years ago due to the accumulated debts from previous companies which were transferred to the state-owned enterprise. Moreover, as the fare is unreasonably low, 2.50-3.50 bahts (US$ 0.10-0.14) for a regular bus trip, revenue does not cover the expenditure causing a loss of up to 1,000 million bahts (US$ 40 million) annually. As a consequence, it is difficult for the BMTA to purchase more new buses to improve its services and it needs a huge subsidy from the government to maintain its operations. Fortunately, in 1992 the government wrote off the BMTA's debt of 12,000 million baht (US$ 500 million) and arranged for the Petroleum Authority of Thailand to provide fuel at a subsidised price.

Despite the existing bus lanes which exist along several main roads, particularly in the inner area, buses are always stuck in traffic jams due to the heavy traffic volume and the weaknesses in bus lane enforcement. Thus, long waits for buses are common and quite often commuters are unable to get on overcrowded buses during peak hours.

Paratransit

As buses are not able to provide a reliable and viable service both in terms of quantity and quality, various paratransit modes have become an alternative for Bangkokians, despite their higher fares and lower safety. Taxis and tuk-tuks are the most common paratransit modes, while less common modes are silor-leks and hired-motorcycles. Taxis are operated by the private sector throughout Bangkok's urban area. Currently, there are two types of taxis, non-metered taxis in which the fare is negotiable and metered taxis which have only been introduced to Bangkok recently but have rapidly become more popular.

There are approximately 7,400 tuk-tuks operating in Bangkok. They mainly serve the inner area. Due to their relatively cheap fare and easy accessibility, they are quite popular among lower income groups. Silor-leks mainly serve sois in suburban areas. Currently, there are around 8,400 operated by the private sector. Hired motorcycles usually serve short trips in sois. But they have recently become more popular among commuters for longer trips along main roads during rush hour as they can zig-zag through traffic. The number has been increasing noticeably.

Railway

The railway is operated by the State Railway of Thailand (SRT). As the system is inter-regional, it contributes very little to urban trips. The average number of daily passengers in the urban area is around 20,000 which is only 0.1 % of Bangkok's 15.6 million daily trips. On the other hand, as it is operated at level grade, there are a number of level crossings with road traffic, triggering worse traffic congestion during peak hour. Thus rail systems are not seen in a favourable light in Bangkok but they offer the most obvious potential to ease the city's traffic problems.

Waterway Transport

The Chao Phraya River and a number of canals in Bangkok provide a comprehensive waterway network. At present they play a minor, although not negligible, role in urban transport. Bangkok residents who live along the banks of Chao Phraya River and the main canals still use this mode of transport as it provides a faster trip with a reasonable fare.

There are three types of service available: express boats, long-tailed boats and ferry boats. Express boats carry passengers along the Chao Phraya river, long-tailed boats cater for passengers who commute into canals and ferry boats provide services for cross-river commuters. All of them are operated by private operators. Waterway transport serves about 260,000 passengers daily which is only about 2 % of Bangkok daily passenger trips (JICA, 1990).

Patronages of boats is limited to those who live close to the river and canals. As there are few routes available at the present time, the number of passengers are still comparatively low, only 4 percent of that bus ridership. In addition, without much intervention from the overseeing authorities, they have set up their own schedules and fare structures (Tanaboriboon, 1993). Furthermore, express boats and ferries are always overcrowded during peak hour leading to high passenger risk. Long-tail boat passengers also take a risk from excessive speed and reckless drivers.

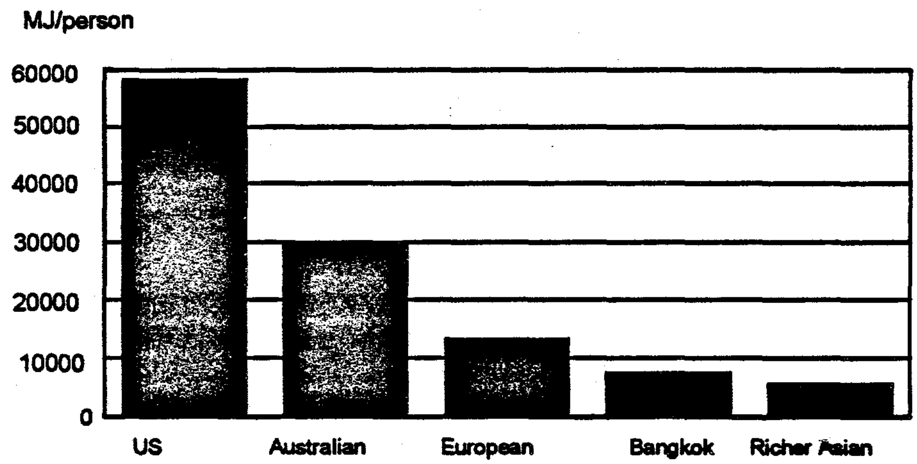
Energy Consumption

One of the key indicators of the level of commitment to the automobile and to motor vehicles in general, is to measure transport energy use. Transportation accounted for nearly 60 percent of petroleum product consumption in Thailand in 1991 of which road transport represented around 85 percent. This portion is large in comparison with other Asian countries. In 1989 the transportation sector in Thailand consumed 56 % of the total national energy demand while it was about 15 % in Korea, 16 percent in Taiwan, 36 percent in Malaysia and 30 percent in Indonesia (TDRI, 1990). It would appear that the car is having a very large impact on Thailand's pattern of energy use relative to other Asian countries. This energy use may not on the whole be being used to foster economic development, but rather to provide limited mobility in cars which would otherwise be better provided by alternative modes.

Bangkok accounts for 50 percent of the whole country's petroleum products consumption and 40 percent of the total road transport energy use. In terms of road transport energy consumption in Bangkok, gasoline is responsible for 41 percent, diesel is 55 percent and liquid petroleum gas (LPG) is 5 percent . Cars and motorcycles account for up to 94 percent of gasoline use. Trucks, pick-ups and buses consume almost all of the diesel while tuk-tuks account for most of the LPG (Sayeg, 1992).

Gasoline use in Bangkok, which is almost entirely consumed by private cars and motorcycle, is about 1.6 thousand millions litres or 7,800 megajules per capita, per year. Although this level is not high in an international comparison, it is higher than richer Asian cities like Singapore Tokyo and Hong Kong (Figure 10) and is an indicator that Bangkok is at one extreme in Asia in its commitment to the private car.

Figure 10. Gasoline Use Per Capita in Bangkok Compared to Other Cities



Note: 1. Bangkok 1990 data
2. Other cities 1980 data

Source : 1. Bangkok calculation based on Petroleum Authority of Thailand 1990 data
2. Other cities from Newman and Kenworthy 1989

Traffic Disaster Analysis

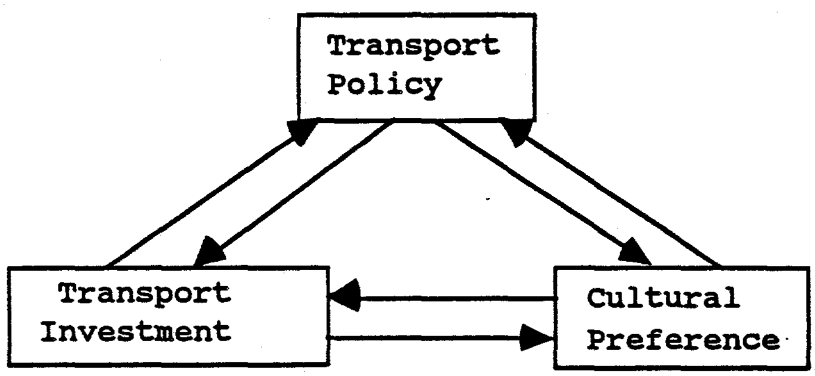
As mentioned earlier, Bangkok is an old city, originally developing as a water-based and walking city. Before World War II the built-up area of the city was only within a radius of 4 or 5 kilometres from the city centre as in traditional walking cities.. Waterways still played an important role and trams and buses were the main modes of motorised transport. There were very few cars on Bangkok's roads. Roads still effectively served both motorised and non-motorised modes of transportation. Bangkok from this perspective was a more livable city for both residents and visitors than it is today.

As described earlier, more roads have been built to cater for cars, including expressways which have been aimed at solving the traffic problem. Unfortunately, they have not worked that way and are unlikely to if the experience of other cities is any indication. Los Angeles is very well known as a city designed around roads, in which about 55 percent of the city surface is covered by roads, and parking lots (Greenpeace, 1993). Yet LA still suffers from serious congestion and air pollution. Furthermore, it has amongst the highest levels of energy consumption for urban transportation in the world (Newman and Kenworthy, 1989).

As Bangkok has grown towards car dependence over more than three decades, it has suffered in several ways. Traffic congestion which occurs on most main roads in Bangkok, especially the inner area, is considered to be at crisis levels. The average travel speed of all vehicles in the whole of Bangkok is now approximately 10 km /h (Halcrow Fox and Associates, 1991). Bicycles in modern cities have average speeds considerably better than this. According to the 1990 study undertaken by the Japan International Cooperation Agency (JICA), the overall travel speed inside the middle ring-road zone averaged only 7.7 km/h. The average speed along the most seriously congested roads is reduced to a mere 3 to 5 km/h. Several times in the past few years traffic has ground to a complete stop for an extended period with the world's first examples of total gridlock. Moreover, it is predicted that by the year 2006 if there are no effective remedial measures, the average travel speed of all vehicles in Bangkok would decline to only 5 km/h (JICA, 1990). This is walking speed - when the traffic is moving!

The move towards a car dependent city can be attributed to at least three factors: (1) transport policy which gives priority to cars and car use (2) cultural preferences which tend to favour this preferences and (3) transport investment in infrastructure which tends to be pushed by both of the above factors.

Figure 11. Factors Contributing to Growing Car Dependence
Source: Newman, 1993



A number of points can be made about Bangkok which relate to transport policy, transport investment and cultural factors:

1. Since Bangkok is an old city and it was not designed for roads, the proportion of its area devoted to road space is very low. Although the proportion of total travel on public transport is slightly higher in Bangkok than in European cities (which have nearly four times more road space), and is very high when compared with American and Australian cities (which have more than ten times Bangkok's road provision), use of public transport in Bangkok is still far from sufficient relative to its limited road provision. This is seen in the comparison to the richer Asian cities. They carry 64% of total passenger travel on

public transport while Bangkok carries half this. However, they have twice as much road provision as Bangkok. *Traffic jams in Bangkok are therefore inevitable because they are attempting to carry too little passenger travel on public transport relative to their provision of roads.*

2. Despite this picture, transport policy has been biased towards road-based transportation, especially car use, by constructing more roads and expressways coupled with low taxes on car purchase and car use. This has encouraged the dramatic increase in number of cars and other private vehicles particularly motorcycles and pick-ups.

3. Parking provision in the Bangkok central business district (CBD) is extremely generous at virtually the same level as American cities and about five times higher than richer Asian cities. In addition, most of these parking spaces are free of charge or charged at very low rates. This provision obviously encourages car use.

4. Buses are the main mode of public transport, yet they cannot provide adequate or reliable services for commuters. Moreover, they get caught up in the traffic jams. As a result they cannot attract people who own private vehicles - if you are going to sit in a traffic jam, better to do it in an air-conditioned car than a crowded, non-air conditioned bus.

5. Other modes of public transport, particularly the non-road-based modes such as water transport and rail receive very little attention, despite their high potential to be viable alternatives for Bangkokians.

6. Walking and cycling which are regarded as the most environmentally friendly modes and which work very effectively in European and richer Asian cities, particularly Tokyo, have a very low share of trips in Bangkok. There are a number of obstacles to cycling and walking in Bangkok. The most serious hindrance is the lack of

infrastructure. As there are almost no bikeways, and there are no ramps at kerbs along footpaths, cyclists must ride on the crowded roads with motor vehicles. A lot of local streets have been widened to cater for cars and no footpath has been left for pedestrians. Severe air pollution and noise is another barrier to cyclists and pedestrians. Creating an attractive walking and cycling environment in Bangkok could be one of the most cost-effective ways of helping to reduce Bangkok's traffic crisis. Singapore now has a strong focus on improvements to the urban environment to attract pedestrians and cyclists (URA, 1991).

7. Bangkokians seem to have a cultural love affair with the car. People buy them as soon as they get a job and often well before they can be adequately financed. They have become a central icon of status in modern Bangkok. To some extent this is common throughout Asia but is particularly marked in Bangkok.

8. The lack of efficient urban and transportation plans and, of more importance, the flaws in their implementation has resulted in haphazard growth. New residential sites in the outer area are beginning to be located where they are not accessible by any modes of public transport or they are very far from employment centres. As a consequence, those inhabitants have to rely on private cars or motorcycles.

9. Surprisingly, over thirty government agencies are responsible for Bangkok's transport policy, management and operation. Moreover, there are three statutory committees and four ad-hoc inter-agency committees to oversee and coordinate the responsible agencies. These overlapping mandates cause great confusion and obstruction to Bangkok transport planning and implementation (Stickland, 1993). A number of proposed projects to solve the traffic congestion have been the subject of serious controversy and are not likely to

eventuate in the foreseeable future. The lack of a planning framework may be a Thai cultural factor but it may not be a necessary factor.

Public Outrage

The traffic in Bangkok has become a very serious issue among Bangkok residents and visitors alike. Bangkokians have to waste from one and a half to two hours to travel a distance of only 10 kilometres. Leaving home before dawn is now very common for Bangkokians.

All political parties make the traffic issue a priority in campaigning, yet only few improvements have materialised. There have been serious conflicts between coalition parties and also between the government agencies. They often use the issue to attack each other which makes Bangkok residents very confused and angry. Letters and articles complaining about this outrageous problem are common in the daily newspapers. Traffic congestion is so serious that even the king has shown concern and, in an attempt to relieve the problem, the king recently donated a sum of money to support traffic police in obtaining better equipment and welfare so they can work more effectively.

At the beginning of this year, there was an unprecedented attempt by prominent members of the public to act on the traffic problem in Bangkok. A group called 'TraffiCrisis'94' headed by the former prime minister Anand Panyarachun was established to brain-storm solutions from communities including the public and private sectors and NGOs. A 62-measure proposal to alleviate the worsening traffic problem was submitted to the government in February. Although the proposal has not been formally implemented, this attempt has been a vital step in community participation in solving traffic problems. The World Bank has recently announced funding for mass transit in Bangkok so the community outrage may already be producing some clear results.

Suggested Solutions

Traditional transport policy and planning focuses on building more roads to keep pace with the soaring number of cars. Roads and freeways seem to relieve traffic in the short-term as they provide more space for cars, yet in the long-run they attract people from other modes and generate new trips leading to more and more cars being purchased and used (Newman and Kenworthy, 1984, 1988). This phenomenon has been noticed in cities around the world, particularly American cities where urban road construction has never been able to keep pace with extra traffic. Since Bangkok has very low road provision, even to raise the level of roads to the same level as the average of the three richer Asian cities, Singapore, Hong Kong and Tokyo (which is still very low in an international perspective), Bangkok's road provision would have to be doubled. Socially and financially, it is quite infeasible to do so, since a huge built-up area would have to be bulldozed which would provoke very serious resistance and require a huge capital investment.

Cars are the least efficient transport mode in terms of people moved for a given amount of road. The following statistics (Table 1) show how many passengers that can pass on a 3-4 metre wide road within one hour (Monheim and Monheim, 1991).

Table 1. Relative Passenger Carrying Efficiency of Different Transport Modes

Mode	*No. of persons/hr on a 3-4 m. wide road*
Walking	20,000
Cycling	13,300
Car	900-2,300
Bus	7,000-10,000
Tram	18,000-25,000
Rapid rail	40,000
Commuter train	50,000

Bangkok has its own unique geography, urban form and culture. Traffic solution options for Bangkok thus should be consistent with these characteristics. Transport policies based on road traffic adopted from other countries in a more advanced stage of development and employed in Bangkok for a long time, have obviously shown themselves to be inadequate for alleviating the traffic congestion. Indeed, they have enormously exacerbated the problem. In order to return Bangkok to being a *city for people not a city for cars*, the transport options should encompass not only financial and technical considerations but also environmental and social advantages. The following policies include such considerations and are therefore suggested to be suitable for Bangkok.

1. Mass rapid transit system

The average density of Bangkok is higher than Tokyo and Singapore but still lower than Hong Kong. In these dense richer Asian cities mass rapid transit systems based primarily on heavy rail systems, have proved to work effectively (see Kenworthy et al, 1994). Los Angeles, a very well known road-based city, has recently tried to solve its notorious traffic and air pollution problem by introducing an urban rail system as an alternative for the commuters, despite its dispersed urban form (commuter rail, subway and light rail combined). Bangkok has very high density in its inner and middle zones. Although the density in the outer zone is lower it is still high enough for effective public transport. As well, the built-up area has been developed mainly along major roads so it has a relatively high density, linear urban form which is able to be served effectively by a mass rapid transit system.

Although mass rapid transit systems (like roads) require a huge investment in construction costs, they provide more reliable, convenient and high profile services. They are also able to recover or exceed their operating costs as in Hong Kong, Manila, Santiago and Seoul(Allport, 1994). Unlike road-based public transport, mass rapid transit does not get caught up in traffic and is usually of a high standard in terms of interior comfort and safety. As a result, it has potential to attract people from cars, including the growing middle class. Furthermore, a mass rapid transit system is more environmentally sound as it contributes very little to air pollution, uses less energy than private transport, if well patronised, and is generally quiet due to electric propulsion. Allport (1994) shows that MRT systems in Asian cities such as Singapore, Hong Kong and Manila have provided the catalyst required to get these cities on a sustainable transport path.

It is clear from the analysis above that the single most effective policy for Bangkok to adopt in the future is the facilitation of a high profile segregated electric rail system.

2. Transit-oriented Land Use Development

Newman, Kenworthy, and Lyons (1990) and Newman and Kenworthy (1991, 1992) have strongly emphasised transit-oriented development as a key planning principle to resist the automobile. This is one of the most vital aspects of the city of tomorrow which aims to reduce the need to travel. Nowhere is it more obvious than in a city like Bangkok already structured for the most part, as a walking city or transit city. The government should therefore give priority and incentive to development projects which will locate close to transit stations. In addition, plans should initiate the establishment of sub-centres which are comprised of high density mixed activities linked by public transport service.

Obviously, in Bangkok where public transport is in a poor state, such planning would have to go hand-in-hand with the development of a reliable, fast mass rapid transit system. The danger is that if centres are established on the basis of high parking and car use, they are hard to turn around even with the advent of good transit. At worst, sub-centres should be based initially on a bus system which has a higher capacity, quality and standard of vehicle (eg air-conditioned), running in its own bus lanes. This would then give way to a higher capacity rail-based system. In Bangkok, with its already large population and high density, it would almost certainly be better to implement some form of rail-based system as the anchor for transit-oriented development at the outset. Again, Allport (1994) emphasises the important of MRT as the catalyst for transit-oriented urban form.

(Kenworthy, et al., 1994) provides a discussion of transit-oriented development in Singapore, Hong Kong and Tokyo and the way in which their centres are predicated upon linkages to the transit system to reduce road traffic and improve accessibility for large numbers of people.

It should also be said that inside the nodes or centres based on transit, walking and cycling would have priority. Activities would be compact and mixed to provide short walking and cycling distance and public spaces would be car free or 'traffic calmed' to ensure an attractive environment.

3. Water transport improvement

Water transport has a very high potential to contribute to transport in Bangkok. Although a number of canals have been filled in, the rest can be improved to serve commuters, particularly on the west bank of the Chao Praya river. The existing services also need to be improved to be more reliable and safe. Moreover, water transport should be integrated with other public transport modes to make it more accessible and convenient.

4. Control of private car use

Any attempt to solve traffic chaos in Bangkok will fail without control of private car use. As Bangkok's road provision is low and very difficult to expand, a high degree of control of car use is apparently unavoidable for Bangkok. The proposed measures could include:

• *Increased vehicle taxes, registration duty and fuel tax.* This measure will discourage people from purchasing new cars and using cars. The tax rate in Thailand is very low compared to cities like Singapore where up to S$ 63,000 has to be paid just for a Certificate of Entitlement for a private car. This measure is also on the principle of '*Let the users pay their real cost*'. Currently car users do not need to pay for their external costs such as damage to the environment, health deterioration from air pollution, impacts on climate change and deaths and injuries from accidents (INFRAS, 1991). Singapore has successfully suppressed its car ownership level relative to wealth through financial measures (Ang, 1991; OECD, 1988)

• *Introduce an Area Licensing Scheme (ALS) to the city centre and some other business centre areas.* This measure works very effectively in Singapore and markedly reduces car traffic in congested areas. Singapore was the first city in the world to apply the ALS idea to curb traffic congestion . After the introduction of this restriction motorised traffic has been estimated to drop by 50 % of the level it would have been without the scheme (Richards, 1990). In 1983 the share of car traffic decreased to 46 % from 56 % in 1975, while the share of buses rose from 33 % to 46 % for travel into the Restricted Zone (OECD, 1988).

• *Consider introduction of Electronic Road Pricing.* Many cities including Hong Kong have investigated the possibility of introducing charges for the use of roads at particular times of day. The idea is that road space is rationed between competing users by levying of an appropriate charge to reflect demand in high periods. The technology is now available to equip roads and cars with sensing devices which would record road usage and motorists would be sent a monthly bill. However, political sensitivities have so far held up this development, even in Hong Kong, although technology is now available to safeguard privacy (see Kenworthy et al, 1994).

5. Provide infrastructure for walking and cycling

To encourage people to walk and cycle more, infrastructure improvement is desperately required. There should be footpaths with shady trees for pedestrians along all roads and footpaths should also be rebuilt along sois where they have been eliminated. Bicycle lanes should be built to facilitate cycling. As a first step, while bicycle lanes are still not available, there should be ramps at the kerbs along all footpaths which cyclists can use along with pedestrians rather than risking going onto the road.

In a number of cities around the world walking and cycling provide great benefits to city living and obtain high priority from governments. For example, in the Netherlands all cities have high cycle useful to priority in traffic and extensive infrastructure , Amsterdam has a very high share of bicycle transport (25-30 %) while in another city, Groningen where in 1979, 50 percent of its residents cycled to work, from 1977 to 1984 bicycle traffic rose by 20 percent (Greenpeace, 1993). Similar success stories are found in Munich, Copenhagen and other cities. Facilities for walking and cycling include pedestrianisation of sizeable parts of urban centres to facilitate walking and cycling. Singapore has a coordinated plan along these lines (URA, 1991). Bangkok needs to move towards full or partial pedestrianisation of its centres together with a plan for cyclists similar to those in the Netherlands as it is structured in a very similar way to Dutch cities (though much bigger).

6. Improvement in paratransit

Generally paratransit in Bangkok which consists of taxis, tuk-tuks, silor-lek and hired motorcycles provides relatively good services to Bangkok residents, particularly those who don't have their own private vehicles and live in areas where formal public transport is not available. Their fare rate is also reasonable. However, to improve their service, there is a need for better integration with formal public transport modes. Paratransit can supply service to bus stops, piers or railway stations and can cater for some public transport commuters and also attract private vehicle users to public transport if the service standard is high enough. Overall, government regulation should be limited to ensuring the standard of vehicle, licensing and safety (Cervero, 1990). In order to encourage paratransit service, some infrastructure should be provided for drivers and passengers such as shelters at pick up points. In addition, as some modes of paratransit such as hired motorcycles and tuk-tuks are likely to render less safe services due to their vehicle characteristics and the recklessness of the drivers, there should be stronger enforcement of traffic laws to minimise accidents. Restrictions on car use can also contribute to paratransit operation because paratransit can effectively be an alternative for car trips.

7. Institutional improvement

A need to revise the functions of all involved agencies and committees is critical, otherwise it is impossible to obtain any progress in traffic improvement. There should be a much smaller number of agencies with responsibility for Bangkok's transport management and operation and each should have a clear-cut function. A single agency should have decisive power to oversee such agencies and have the authority for recommending decision-making to the government.

One major barrier to achieving consistent policy and effective implementation for traffic improvement in Bangkok is the lack of public understanding and participation. The government should therefore provide comprehensive and unbiased information on the main plans and projects to the public. Public hearings should also be conducted as in other countries during the decision- making process to minimise the serious conflicts which are occurring at present just between agencies. Public involvement can resolve the power plays of agencies as they are able to show what are the real issues. The 'Traffic Crisis 94" group has demonstrated its ability to provide such positive input.

Conclusion

Traditional urban and transport policy which relies on road-based planning has been proven inadequate for tacking Bangkok's traffic chaos. After employing such policy for more than three decades Bangkok traffic has become a diaster and the city has become notorious world-wide for its traffic congestion and air pollution. The simplistic application of there largely American models took little consideration if any of the walking city and transit city structure of Bangkok.

The policies recommended above rely on the awareness of Bangkok's unique characteristics and also encompass social and environmental aspects. The worldwide comparison has contributed substantially to more insight in selecting the appropriate measures for Bangkok. The introduction of a mass rapid transit system, water transport improvement, control of car use, provision of infrastructure for walking and cycling, improvement in paratransit together with transit-oriented land use development are believed to be able to work effectively in Bangkok. Nevertheless, institutional improvement including public participation is very necessary to achieve these urban planning and transport strategies. With the combination of these sustainable urban and transport policies, it is possible for Bangkok to be converted into a city for people again, though it will take probably 10 to 20 years or more for substantial improvements.

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THE TRAFFIC CRISIS AND A TALE OF TWO CITIES: TRAFFIC AND AIR QUALITY IN BANGKOK AND MEXICO CITY

By V. Setty Pendakur, Madha G. Badami

Mega Cities

Asia and Latin America are the most dynamic economic regions of the world. While their population growth rates are either decreasing or steady, the economic growth rates are higher than in the other regions. This growth is expected to continue well into the next decade. Megacities are growing at unprecedented high rates, doubling their populations every 15-20 years. Increasing incomes, perception of better opportunities, and the primacy of these megacities, have increased their populations and motorisation. Motor cars have been growing at 10-12 % annually while motorcycles have been growing at 15-20 % annually. This combination has been deadly, resulting in increasing congestion and deteriorating air quality. Congestion management techniques have not changed significantly in most megacities during the past two decades. Bangkok and Mexico City now have the world's worst traffic and air quality conditions.

This paper focuses on congestion management techniques, traffic congestion levels and air quality. By using data from Bangkok and Mexico City, it illustrates the need for drastic changes in transportation policy tools and techniques for congestion management and for improving environmental quality. New approaches to investment and regulatory policy analysis and implementation are suggested. This requires the inclusion of all costs and benefits (economic and ecological) in the policy matrix so that investment and regulatory policies act in unison.

Table 1. Bangkok and Mexico City Population, Economy and Transport

	Bangkok	Mexico City
City Population		
1990	8 Million	20 Million
2000	10 Million	26 Million
Per Captial GDP US$ 1990	4420	3120
As % of Country Per Capita GDP US$ 1990	315%	220%
GDP Annual Growth Rates 1980-1990	9-15%	4-8%
Total Motor Vehicles 1990	2.8 Million	2.6 Million
Cars		
1990	1.2 Million	2.4 Million
2000	2.0 Million	3.2 Million
Cars as % of Country Total 1990	50%	68%
Motor Vehicle Annual Growth Rate 1980-90		
Cars	12%	5%
Motorcycles	18%	N/A
All Vehicles	15%	7%

Sources: United Nations, 1991; World Bank, 1992; data compiled by the author from various sources.

Megacities are dominant in social, political and economic terms. 30 to 60 % of national GDP is typically produced in these cities. Their human and motor vehicle populations have been doubling every 15-20 and 6-10 years respectively. They also have the most severe traffic congestion and air quality problems. They have the nation's highest incidence of poverty and absolute poverty (Pendakur, 1992). Large portions of their populations endure severely unhealthy housing and sanitation conditions (Camp, 1991). Following are important characteristics of urban transportation systems in the megacities:

- the city centres are heavily congested with motorised traffic
- traffic crawl rates vary from 2 to 10 km/h
- car and motorcycle ownership are increasing at annual rates of 10-12 % and 15-20 % respectively
- significant air pollution with no relief in sight
- TDM strategies are primarily creating new supply of road capacity
- fairly high transit trips with substantial transit investments
- weak air pollution monitoring and enforcement
- fairly cheap fuel and high costs of vehicles

Table 1 shows the population, economic and motor vehicle data for Bangkok and Mexico City. Bangkok has 15 % of Thailand's population and 50 % of its motor vehicles. Human population is growing at 2 % annually, and motor vehicles at 15 % (cars 12 % and motorcycles 18 %). Mexico City has 22 % of the nation's population and 68 % of its private cars. The human and car populations are expected to grow rapidly by 25 % in 10 years. Both cities are primate economically and demographically. Both are motor vehicle dominated, with serious consequences for urban form, energy use and air quality (Hanson, 1989; Hanson, 1992).

Table 2. Bangkok Traffic

- Of all daily person trips in 1991: 28% car, 32% bus, 9% hired vehicles, 15% motorcycles, and 16% walk. Walk trips are generally short trips
- Peak hour average for Central Area - 18Km/h
- Peak hour average for CBD - 6-10Km/h
- Peak hour worst crawl rate - 1-2 Km/h
- Peak hour worst condition -- Rama 9 and Asoke, crawl rate 1.2 Km/h, can take 30-45 minutes for 600 meters
- Peak hour suburban crawl airport to Rangsit, 15Km, can take 15-150 minutes
- Each car typically spends an equivalent of 44 days each year in traffic jams
- Congestion-caused delays cost $4 million daily, or 33% of the city's potential GDP
- If peak-hour car trips decreased 10%, annual time savings would be $400 million
- Traffic Control Systems -- Manual by police to operate signal timings. No ATC system at present but planned
- Exclusive bus lanes -- Not enforced regularly. Contra flow lanes -- enforced fully

Sources: Author's data files; Expressway and Rapid Transit Authority of Thailand; Metropolitan Bangkok Traffic Police; Pendakur, 1993; and Stickland, 1993.

Table 3. Bangkok Air Quality

- 70 % of pollution derived from vehicles
- SPM – 200-400% of WHO standard
- 97 Days SPM > WHO Standard
- CO – 50% higher than WHO standard
- Pollution control measures – Not Enforced
- Street level air pollution 8-hour exposure to street level air equivalent to smoking 9 cigarettes per day
- Most exposed people to air pollution: traffic police, tuk tuk and motorcycles, taxi drivers/passengers, street vendors
- Public health indicator: Among 1758 total traffic police 753 suffer from respiratory diseases, 420 have been suffering > 5 Years
- Environmental costs of air pollution – estimated at $ 2 billion a year
- Excessive lead levels (primarily from vehicles) contribute to: 200,000-400,000 hypertension cases, approximately 400 deaths annually, 4 or more IQ points drop in children by Age 7 with long-term implications for their productivity as adults
- Global mega cities Air Quality Rating – 2/10

Sources: Compiled by the author from Thai Government, Metropolitan Bangkok Traffic Police and Population Crisis Committee documents; Pendakur, 1993; and Stickland, 1993.

Bangkok: Traffic and Air Quality

Tables 2 and 3 show the traffic and air quality conditions in Bangkok. It is not unusual for a trip of 30 km, from the airport to the CBD, to take anywhere from one to three hours, even with a limited access toll freeway. Many car owners use leaded gasoline because it is about 10 % cheaper. Congestion costs are very high. Peak hour average traffic flow in the central business district is 10 km/h and crawl rates over significant stretches of streets are only 1-2 km/h. Congestion costs are estimated at more than 1 billion US dollars annually. If peak hour motorised trips could be reduced by only 10 %, annual savings would be as much as an estimated 400 million US dollars.

Motorised trips are expected to increase from 7 million in 1990 to 11.3 million in 2000. 35 % of all person trips are by private motor vehicles (cars and motorcycles), which in turn account for 70 % of air pollution. Carbon monoxide (CO), and suspended particulate matter (SPM) levels are very high and far exceed WHO standards. Smoke from traffic is often bad enough that the reductions in visibility is a safety hazard (WHO, 1992).

Roadside air pollution is quite serious. The maximum 24-hour mean SPM reading reported in 1988 was 1,400 micrograms per cubic meter, which is more than four times the Thai national standard of 330 micrograms per cubic meter (WHO, 1992). The people most severely affected are pedestrians, street vendors and traffic police (Pendakur, 1993). Tables 2 and 3 show the high costs of current congestion management techniques, both short and long term.

Bangkok's environmental problems are quite serious and are set to become worse. SPM ranges from 2 to 4 times the WHO standard. Carbon monoxide levels are 50 % higher and lead levels are double the acceptable WHO levels. Greenhouse gas emissions are far above the average for the level of economic development. Although the per capita emissions of carbon dioxide and methane, and CFC use, are lower than in industrialised countries, Bangkok is far worse than cities in many other developing and industrialised countries in terms of air quality (Panayatou and Phantumavanit, 1991).

Because of the absence of lead emitting industrial sources, all lead emissions come from gasoline. Lead emissions are now estimated at 500-1,000 tons per year by the Thai government (Panayatou and Phantumvanit, 1991) while World Bank estimates indicate much higher levels -- 20,000 tons (Faiz et al, 1992). Ozone is not a problem in Bangkok because year-round monsoon winds prevent its build up. In areas of heavy traffic, a large portion of the SPM is of inhalable size (lower than 10 microns), resulting in serious respiratory problems such as asthma, bronchitis and conjunctivitis.

Mexico City: Traffic and Air Quality

Tables 4 and 5 show the traffic and air quality conditions in Mexico City. Peak hour traffic flows are around 10-13 km/h in the central area and 20 km/h in the outskirts. 23 % of the trips are by private car and account for 45 % of the total pollution attributable to transport. Transport is responsible for 77 % of the total air emissions and the car population is expected to increase by 25 % in 10 years.

Mexico City is the most polluted metropolis in the world. Its geography is an aggravating factor because of the frequent thermal inversions. The most serious problem is the high ozone level. During 1986-89, WHO ozone guidelines were exceeded as many as 254 days per year. In 1991, the residents of Mexico were exposed to 1,400 hours of high ozone levels, far exceeding the WHO guideline of one hour per year (The Province, 1992). The high ozone days often mean a 30-50 % power cut to industries, loss of income for workers, school closures, and yet there is no evidence of any serious reduction in private car traffic. Table 4 and 5 show the enormous long- and short-term costs of current transportation demand management strategies.

Emission standards for gasoline vehicles were quite permissive until recently. From model year 1993 onwards, the maximum allowable emissions have been lowered to 2.11 g/km. However, this does not apply to the 2.6 million cars already on the roads now. Recent assessments indicate that average car CO emissions are as high as 60 g/km. This situation is further aggravated by the fact that 43 % of the cars on the road now are over 10 years old, with practically no pollution control devices. Furthermore, many cars use leaded fuel even in unleaded-type vehicles (DDF, 1989). Mexico City has 40 % of the cars Los Angeles does, but three times the air pollution !

Table 4. Mexico City Traffic

- Of All Daily Person-trips in 1991: 23 % Private Car, 4 % Taxi, 40 % Bus (Ruta-100, Combis, Microbus, Trolleybus), 14 % Subway and LRT, and 19 % Walk
- Peak-hour Traffic Flow Average: 10 km/h within CBD, 13 km/h in the Central Area, and 20 km/h in the Outskirts
- Daily Person-trips by Private Car: Total 7.7 Millions and 76 Million Passenger-kilometers; by Taxi 1.25 Millions and 6.7 Million Passenger-kilometers
- There are Currently 2.6 Million Cars and 0.6 Million Commercial Vehicles. In 1990, 43 % of the Private Cars were More than 10 Years Old, with Virtually No Pollution Control.
- % of the Population Own Cars, Equal to 1 Car per 7.7 Persons
- In 1990, "Hoy No Circula" Scheme ("One Day Without a Car") was Implemented. But Many People have Purchased an Additional Old Car. In 1990, while New Vehicles sold in the Federal District Numbered Only 123,000, New Registrations were 320,000. The Net Result is an Increase in Old (and More Polluting) Cars.
- There are Two Vehicle Taxes, One on New Cars, and Another, an Ownership Tax called "Tenencia", Paid Annually. This becomes Zero for Vehicles 10 or More Years Old. It is thus Economically Attractive to Purchase Old Vehicles to Avoid the One Day per Week Ban, and generally Encourages the Use of Old and Highly Polluting Cars.
- Leaded Gasoline is 30 % Cheaper than Unleaded, which Makes it Worthwhile to Misfuel Vehicles with Catalytic Convertors with Leaded Gasoline, and Install a New Convertor in Time for the Annual Inspection

Sources: Humberto Bravo et al, 1991; Carbajo, 1993; Pendakur, 1993.

Table 5. Mexico City Air Quality

- Mexico City's Geography Aggravates its Severe Pollution Problem. Because it is Surrounded by Mountains, Ventilation is Poor, and Thermal Inversions are Frequent (25 Days per Month between November and May).
- Mexico City is the Most Polluted City in the World.
- Average Pollution is 0.27 Tons/person/year, Twice the Level in the Next Most Polluted City in Latin America, Sao Paulo.
- Transport's Contribution to Total Air Emissions is 77%. It Causes 97 % of CO, 75 % of No_x, 52 % of NMHC, and only 22 % of SO_2 and 2 % of SPM.
- % of the Car Population of Los Angeles, but 3 times the Air Pollution.
- When Ozone Levels are Very High (0.35 ppm)
  30 % Power Cut to Industries
  School Outdoor Activity Suspended
  Citizens are *Urged* to Use Public Transport
  Cars are Still Used
- The Most Serious Pollution Problem in Mexico City is that due to Ozone, both in terms of Frequency and Duration of Episodes. In the Southwest of the City, where the Highest Ozone Concentrations are Caused (by Wind Transport), National Standards were Exceeded around 60-80 % of the Days Each Year between 1986 and 1989. In the Same Period, the Levels were Exceeded at Least 4 Hours Daily on Average.

Sources: Carbajo, 1993; Faiz and Aloisi de Larderel, 1993; Romieu et al, 1991; WHO, 1992.

URBAN LIVING STANDARDS

The Population Crisis Committee has evaluated the quality of living in the 100 largest metropolitan centres with more than 2 million people. 35 of these cities were in Asia (Camp, 1991). Table 6 shows current air pollution levels in Mexico City and WHO standards for various pollutants. In all cases, standards are exceeded, and air quality is deteriorating daily.

Table 6. Ambient Pollutant Levels in Mexico City, 1986-1991

Pollutant	Concentration Range	WHO Guideline/ Standard
SO_2	Annual Mean 80-200 µg/m^3 Daily Max 200-550 µg/m	Annual Mean 40-60 µg/m^3 (WHO)
SPM	Annual Mean 100-600 µg/m^3	Annual Mean 60-90 µg/m^3 (WHO)
Lead	Annual Mean 0-4 µg/m^3	Annual Mean 0.5-1 µg/m^3 (WHO)
CO	8 Hour Max. 10-36 mg/m^3	8 Hour Max. 10 mg/m^3 (WHO)
NO_2	1 Hour Max. 301-714 µg/m^3	1 Hour Max. 400 µg/m^3 (WHO) 395 µg/m^3 (Mexico)
O_3	1 Hour Max. Often 600 µg/m^3 Occasionally 850-900 µg/m^3	1 Hour Max. 150-200 µg/m^3 (WHO) 0.11 ppm (Mexico) 220 µg/m^3 (Mexico)

Sources: WHO, 1992; Faiz et al, 1992.

Table 7 shows the urban living standards in several cities. Mexico City has the worst ozone levels in the world. In 1991, there were 97 days when SPM levels far exceeded WHO standards. Mexico City inhabitants were exposed to over 1,400 hours of high ozone levels during 145 days in 1991. The situation was equally bad in two other Latin American cities: Sao Paulo and Santiago.

URBAN TRANSPORT POLICY AND PLANNING

In megacities such as Mexico City and Bangkok, urban travel has become the worst ordeal of the day. Investment and regulatory policy responses in most cities, with the notable exception of Singapore, have focused primarily on facilitating automobile use. In some cities, there are efforts to increase the capacity of transit systems and also build new LRT/MRT systems.

What are the social, environmental and economic consequences of this kind of urban living Can these cities sustain for any length of time without a total collapse of the system? There are significant social consequences in terms of dislocation, fatigue and long hours. The public health consequences because of environmental degradation have been well documented by several organizations, including the United Nations (UNEP, 1988; Camp, 1991). Recent submissions to the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, show that in one year, Bangkok traffic jams cost an estimated US $ 1 billion in extra fuel burned and work time lost.

Table 7. Urban Living Standards: Selected Cities, 1990

City	Population (Millions)	Levels of Ambient Noise	Traffic Flow Peak Hour (km/h)	Air Quality and Pollution Exceedence
1. Mexico City	20	6	13	0.40 ppm O_3
2. Tokyo	18	4	45	0.07 ppm O_3
3. Sao Paulo	17	6	24	0.15 ppm O_3
4. Shanghai	13	5	24	16 days SO_2
5. Calcutta	12	4	21	268 days SPM
6. Buenos Aires	12	3	48	0.06 ppm O_3
7. Bombay	11	5	16	100 days SPM
8. Seoul	11	7	22	87 days SO_2
9. Beijing	11	4	42	272 days SPM
10. Bangkok	8	2	10	97 days SPM
11. Singapore	3	7	38	45 days$\mu g/m^3$ NO_2

* Subjective Rating 1-10. Noisiest Rating 1 => 90 dBA, 10 < 60 dBA

Source: Camp, 1991.

And it should be remembered that Bangkok, even without vehicle emissions, is an already badly polluted city (Asiaweek, 1992). If these cities are to sustain and survive, there has to be a new policy regime that focuses on including all costs and benefits (economic, social and environmental) associated with transport mode choice. Further, this regime should be structured to be flexible and dynamic over time, and should help foster efficiency, equity and sustainability. Figures 1 to 4 below outline the new policy approaches necessary for sustainable cities. Figure 1 shows that the primary requisite for developing sustainable urban transport in the megacities is to dynamically construct complementary investment and regulatory policies that are: economically efficient, ecologically sustainable, socially equitable.

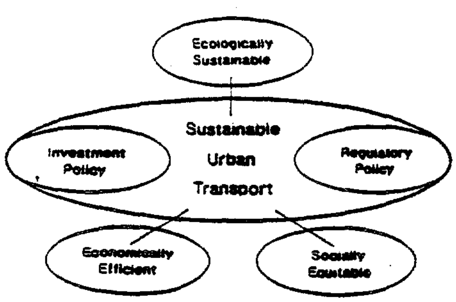

Fig. 1 Urban Transport Policy Spectrum.

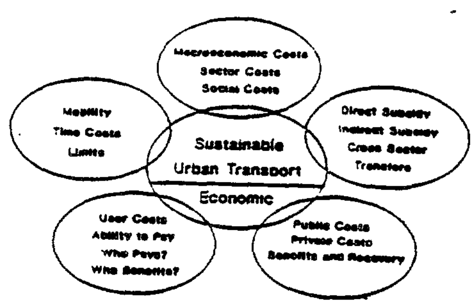

Fig. 2 Sustainable Urban Transport (Economic System).

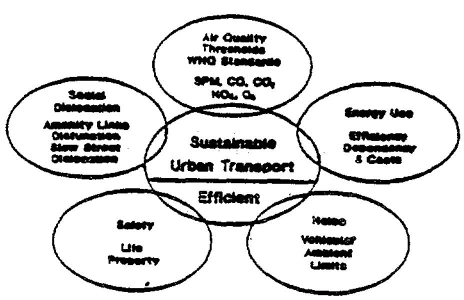

Fig. 3 Sustainable Urban Transport (Environmental System).

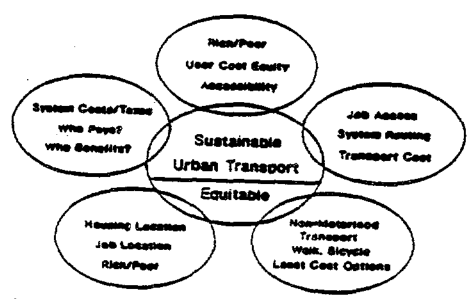

Fig. 4 Sustainable Urban Transport (Equity Considerations).

This requires a systematic and dynamic balancing of the three components, all of which include externalities. Figure 2 shows the elements of an economically efficient sustainable transport system. This approach requires that:

- macroeconomic costs include sector costs and social costs
- all subsidies, direct and indirect, and cross-sector transfers are calculated and balanced against benefits to the environment and humans
- public and private costs are calculated and recovered from all beneficiaries
- user costs are also related to equity considerations while aiming for minimum average mobility and time savings, public policy not encourage large travel distances which necessitate efforts to save time for motorists. Thus, thresholds for time savings must be established.

Figure 3 shows the construct of an ecologically sustainable system. This requires that analysis and policy approaches:

- establish air quality thresholds, particularly for CO, CO_2, SPM, SO_2, NO_x and O_3
- establish clearly defined energy policies that stress conservation and reduced dependency on imported fuels
- establish noise thresholds
- define safety thresholds for both life and property
- do not permit social dislocation, degradation and dysfunction in the name of maximizing time efficiency of transport
- assign top priority to energy-efficient and low-pollution modes such as NMT and HOV

Figure 4 outlines the socially equitable urban transport system. This calls for analysis and policy to:

- establish clear limits to costs and cost recovery in terms of the ability of the poor to pay higher transport costs
- provide for access to employment by the poor, and allocate high priority to the modes that they use
- consider non-transport solutions to transport problems, such as reducing trip lengths by co-ordinating housing and job locations
- ensure that system costs and benefits are spread equitably across the population

Most developing countries are in the tropics and their hot climates aggravate evaporative emissions, contributing to tropospheric ozone (in Mexico City, altitude is an additional factor). There is urgent need to control gasoline volatility, and to initiate crankcase and evaporative emission controls. Lead in gasoline and sulphur in diesel should both be reduced (Faiz and Aloisi de Larderel, 1993). Reducing lead content in gasoline could be considered separately from requiring catalytic convertors.

The new system will require that investment and regulatory policies be co-ordinated, and also that direct and indirect costs be viewed comprehensively. Such an approach will call for demand management with the objective of reducing motorised traffic volumes generally and more particularly during peak hours and in heavy traffic areas, and rigorous regulation of polluting sources as well as polluters. This will entail lower emission vehicles, improved vehicle maintenance, improved fuel quality, users shouldering direct and indirect costs, land use policies that result in reductions in trips and trip distances, increased use of non-motorized modes, and reduction in single-occupancy motorised vehicle trips. The Singapore experience over the last 20 years in achieving goals along these lines by using strict economic measures indicates that it can be done (Pendakur, 1993).

More fundamentally, however, a complete overhaul of the intellectual and analytical bases of transportation policy and planning that have been in vogue since the late fifties is called for. These approaches have become obsolete with the new knowledge in terms of environmental, social and public health costs. And if such a drastic overhaul does not happen soon, it may well be

THE END OF THE ROAD !

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BANGKOK AND ITS AIR POLLUTION PROBLEM

By Sangsant Panich

Site Characteristics with Respect to Air and Noise Pollution

Bangkok is the city on a former river delta and is a very flat area. The topography is unremarkable but being only a few kilometers (about 20) from the sea in the Gulf of Bangkok, the City experiences the sea breeze every afternoons and evenings. The natural phenomenon is caused by the uplifting of hot air from the sun-baked ground and heat generation in the city, to be replaced by the cooler air from the sea, which is to the South. During the nighttime the sea breeze ceases to operate as the ground temperature cools down. The late night and early morning is characterized by the calm or no wind.

The Monsoon winds are the seasonal winds which flows from Southwest to Northeast direction during Summer (February to October) and reverse during the winter (November to January). They are caused by large scale movements involving the Asia continent and the Indian Ocean. It can be seen that during the summer, the monsoon wind augments the sea breeze in Bangkok, so every afternoons during summer the wind is brisk, and the Thai people regard the season as suitable for flying kites. In the winter, however, the monsoon wind is from the Northeast which is against the sea breeze from the South, so in the winter the wind may change directions, such as having a Southerly wind during the cold, early morning, followed by a warm sea breeze in the afternoon, and calm condition at nighttime.

The air pollution episodes are most severe in the winter time, due to the fact that the wind is weak and its changing direction may bring the pollutants back into the city. The dry condition in winter also produce a lot of dust (technically called suspended particulate matter, or SPM).

The rainy season in Bangkok starts as early as June, even though the period is dominated by the Southwest monsoon wind, which can also be regarded as part of the summer season. The rain is brought by the humid air from the sea in the South. The period of intense rain is the months of August to September. The latter part of the rainy period is dominated by the depressions (originated by typhoons) from the South China Sea to the East of Vietnam which also bring heavy rain to the country of Thailand. During the rainy season, the roads are sometimes flooded temporarily and traffic conditions can be much worse than usual. The water on the road surface keeps the ground cool, and surface temperature inversion can be observed especially in the evenings, to be about 50 meters from the ground and vehicles' exhaust can be seen trapped in the layer. This is also a natural phenomenon of cold air near the ground not rising and thus traps air pollutants. It is interesting as there is usually no inversion in Bangkok without the rain, as the city is always producing and absorbing heat, so the air near the ground is always rising and inversion is not observed even during the winter.

The characteristics of Bangkok as the large heat producing region (termed "heat island") also produce climate effects. In addition to the sea breeze, the uplifting of hot air during the daytime also carry the pollutants in the air mass , notably the dust. The dust of Bangkok contains mostly the black smoke from diesel engines and road dust (about 40 % each) and small amount of sea salt (about 5 %) and secondary particles. Secondary particles originate from gaseous pollutants which transform in the air to other chemicals, notable sulfates and nitrates. They are good as cloud precipitators. It is usual for the rain in Bangkok to occur during the early evenings, part of this reason may be due to the cloud precipitation from these chemicals.

THE POLLUTERS

Even though Bangkok has more the 20,00 registered factories, the most in the country, air pollution from the factories are not as serious as the one from traffic. The industrial activity in Bangkok is usually small and not energy intensive. The main user of fuel in this category is electricity generation (2,900 million litres per year of fuel oil, less than 2 % sulfur content). However, the sulfur dioxide problem is still small comparing to the traffic generated ones.

With 2.1 million vehicles, the city has a serious problem of carbon monoxide from the gasoline vehicles stuck in the traffic on start and-stop cycles, while particulate matter is the result of diesel vehicles. Hydrocarbons mainly result from two-stroke motorcycles and tuk-tuk (three-wheeled) taxis. The air pollution study and breakdown of emission sources are being under study by the Department of Pollution Control, USAID and the World Bank.

Air pollution in Bangkok and major cities of Thailand is the result of emissions from gasoline, diesel, and LPG fueled vehicles, which contribute to the observed levels of carbon monoxide, lead, particulate matter, sulfur dioxide, nitrogen dioxide, ozone and hydrocarbons. The industrial activities contribute smaller share due to tall stacks and more efficient combusting processes and pollution control.

The observed levels of pollutants in the streets depend on the amount of traffic volume, local meteorological conditions, and the fuel quality. Plume rise in the streets is dominated by rapid initial movement vertically due to heat transfer radiationally from road surfaces, and thus the tendency to lower the concentration of pollutants at ground levels but the effects will be higher at elevated receptors, i.e. those living in upper floors of shophouses which line the streets.

For particulate matter and lead, the effect of deposition to the ground and re-entering the atmosphere may be important:

- **Carbon Monoxide**

Carbon monoxide is colourless and odourless gas emitted mainly from the incomplete combustion of gasoline in the internal combustion engines (cars). The major health effects are the results of its ability to combine to haemoglobin in the blood, which loafer the blood's ability to transfer oxygen from lung to other tissues. At small doses (8-28 ppm for 8 hours) it results in impairment of visual and time interval discrimination, and physiological stress in patients with heath diseases. The ambient air quality standards of Thailand for this gas are : 20 mg/cu.m (17 ppm) for 8-hour average, and 50 mg/cu.m (40 ppm) for 1-hour average. In comparison, the US Environmental Protection Agency (US.EPA) standards are 10 mg/cu.m (9 ppm) and 40 mg/cu.m (35 ppm) for 8- and 1-hour averages respectively, and should not be exceeded more than once per year. For Taiwan, the target for 1996 is 10 ppm. for 8-hour average. At the present, Department of Pollution Control (DPC, and formerly named Office of the National Environment Board, or ONEB) is proposing 10 ppm standard for an 8-hour period and 35 ppm for 1 hour period.

The reason for standards of the range 9 - 17 ppm for an 8-hour average is obvious. With the carbon monoxide concentration in the range, and an exposure hours of 8 hours, will result in 2 % or less of carboxyhaemoglobin in the bloodstream of human (According to the experiment by Peterson, 1977, Industrial Health, Pentrice Hall). This level is considered to be below the threshold level which causes health effects on heart disease patients.

From past monitoring records of Office of the National Environment Board and Department of Pollution Control, it can be summarized that in the residential areas of Bangkok, the levels of carbon monoxide are generally very low and usually stay within 1 - 2 mg/cu.m. which do not cause observable health effects. Curbside monitorings yielded higher values, with the following notes:

The concentrations of carbon monoxide seem to be site specific, that is, the levels at some places are consistency high while the other sites are consistency low in CO concentrations. The "high level" sites are Pratunam intersection, Yaowaraj; Old Market, Bamrungmuang Road, Sapan Kwai intersection, and Silom Road (front of Bangkok Christian Hospital). The levels observed at those places are 8 - 13 mg./cu.m for the daily averages, but high values of 20 has been reported at Sapan Kwai, and 19 at Silom Road, which are on the par with the Thai ambient air quality standards, and far exceed the standards of other countries mentioned above.

Even though the concentration of carbon monoxide reaches its peak during rush hours, but in the past few years the concentration remains high throughout the day, as the traffic volume reaches road capacity almost all of the day, from 6 A.M. to 10 P.M. at most stations.

Measurements by Jenwitheesuk (1986) under supervision of the present author, at Siam Center and Wat Phrayayoung School on Rama VI Road, were done at curbside with different heights. It was found that if we take the ground level of CO as 1.00, the 3.5 m. elevation would be 20 - 80 % higher and such higher concentrations prevail until the elevation of 7.5 m. At the altitude of 10.5 m. the concentration drops down to the same, or less than ground level concentration. This indicates plume rise of vehicular exhausts to higher altitudes at a very rapid rate and explains why there are not much accumulations of pollutants in the curbside and street level. However the increased concentration in the 3 - 8 m. altitudes means higher risk for people living in the second to fourth storey of the shophouses. Since the ground level concentrations of CO are already high at ground level in many places in Bangkok, the increase of 20 - 80 % at higher altitudes will produce high risk to the residents, considering that they live there all day long. For example, the ground level concentration of 20 mg/cu.m may mean 30 mg/cu.m at the third storey of a shophouse.

The effect of meteorological parameter does seem to be important in sites which are well-ventilated. For sites such as Silom Road, for example, which are characterized by tall buildings and all-day traffic congestion, the day-to-day concentrations do not vary much as outside wind has less effect on the air circulation in such "valleys".

It is observed that for congested streets where carbon monoxide exceeded ambient air quality standards as stated above there have been no trends of increasing concentrations in the past few years. The simple explanation is that the traffic conditions in those places have long reached the critical levels and there had been no increase in traffic volume in those areas for some times. It is also noted that since Bangkok's streets are usually built far apart (thus create very long blocks of buildings without adequate connecting roads- or superblocks), the horizontal transfer of pollutants from one street to another or the others are not contributing much, as evidenced by low concentrations of pollutants in residential areas. The observed level of pollutant in any street is thus mainly the result of pollutant generated in that particular street.

- **Particulate Matter**

The particulate matter in the ambient air has been monitored by DPC and the Department of Health, both at curbsides and in other areas. The sampling method of high volume gravimetric requires 24 hours per sample, and thus it is not possible to obtain short time average like carbon monoxide. Since particulate matter is regarded as longterm health hazards and nuisance problem, it is better to look at the long term trends rather than the short term one.

While it is debatable on the health effect of particulate matter (as it is probably more important to address the content of the particulate matter), the ambient air quality standards of Thailand are 0.33 mg/cu.m and 0.10 mg/cu.m for 24-hour average and annual (geometric mean) average, respectively. US. EPA old standard set levels of 0.26 and 0.075 mg/cu.m for the equivalent standards. It is noted that most of other countries' standards fall into these ranges. (US.EPA now adopts the standards for PM-10, particulates under 10 micron in size).

The Study on the Air Quality Management Planning for the Samut Prakarn Industrial District (JICA, 1990) reported contents of particulate matter in that province (which is part of the Bangkok Metropolitan vicinity) to be about 40 % diesel smoke and 40 % road or soil dust, with other minor constituents. As the study was done by the methods of chemical balance, a level of uncertainty was also observed. However, the results of monitoring on the curbsides and in residential areas have led to the following results:

1. The levels of particulate matter at residential and other areas which are not adjacent to the streets (at least 50 m. away) show trend of increasing during the past 8 years. Since 1989 all stations of ONEB and DOH reported more than 0.100 mg/ cu.m for the annual average (range 0.1 -

0.12) which is the standard for Thailand, and significantly higher than the former standard of US. EPA.

2. For such stations, the concentration of particulate matter exhibits annual variation in which the winter (Nov.-Jan.) produces higher concentration than other seasons. This is due to the dry surface of the ground.

3. For curbside monitoring, the 24-hour samplings were done at certain time intervals in a year, thus annual mean can not be determined. It was noted that the standard of 0.33 mg/cu.m. was violated at all sites conducted by ONEB during 1987-present. However there are high variation on the day-to-day basis (unlike carbon monoxide where the day-to-day concentration is not much different). This is explained by the fact that much of the measured particulate matter came from the re-entering process from street dust, thus the rain, washing and sweeping of the streets can highly effect daily or next day's concentration. Due to this reason, there is no observable trend of particulate matter at the curbsides.

- Lead

Lead in the ambient air of Bangkok in 1990 is about 380 tons per year, as calculated from the automobile' gasoline use (360 tons) and industry (20 tons). Since lead is considered toxic to human health, as it can produce anemia (at blood concentration above 40 microgram/100 cc.) and hypertension, there have been many efforts to reduce lead in the gasoline in the past, such as the reduction from 0.84 g/l of gasoline to 0.45 g/l in 1984, and subsequent reduction (0.4 g/l in 1991 and the introduction of premium unleaded gasoline in 1991, and further reduction of lead to 0.15 g/l in 1993 for premium leaded gasoline). At the present, premium unleaded gasoline captures a share of about 60 % of the market for premium gasoline in Bangkok.

Monitoring of lead in the atmosphere is done in conjunction with the particulate matter monitoring, using wet ashing of the same sample (US.EPA's method). The followings are summary of the findings from secondary data:

1. The average atmospheric lead in Bangkok is about 0.5 microgram/cu.m for the areas not adjacent to the streets. This is considerably less than the Thai ambient air quality standards of 10 microgram/cu.m. (daily) and the US.EPA standard (1.5 microgram/cu.m on 3 month average). It was proved in a very detailed study by Boonyarit (1991) that there are a very high multiple relationship between atmospheric lead level and calm wind occurrence, and the emissions of lead from automobiles in Bangkok, as well as there are clear evidence for long range transport by the wind across the city, in the wind direction.

2. The curbside lead level was found to be highest at Bamrungmuang Rd. at 5.45 microgram/cu.m., but the average levels in Bangkok streets are 2-3 microgram/cu.m. The fluctuations of data are high on the day-to-day basis, with the same reason as explained for particulate matter (re-entering to the atmosphere by vehicles' movement). Since the concentrations are higher than the US.EPA standards of 1.5 microgram/cu.m., some concerns on public health are well justified.

- **Sulfur Dioxide**

Sulfur dioxide is the toxic gas which damage pulmonary (lung) function by synergistic effect with particulate matter. At the levels as low as 0.055 mg/cu.m (0.02 ppm) with particulate matter of 0.18 mg/cu.m., can cause increased respiratory symptoms (Ferris, 1978 as quoted earlier). The ambient air quality standards for Thailand are 0.300 mg/cu.m. (24 hour average) and 0.100 mg/cu.m. (annual average), while the US.EPA standards are 0.365 and 0.08 respectively.

In Thailand, the monitoring results are scarce since the cost of monitoring this gas is expensive. However, limited data in Bangkok and Samut Prakarn (industrial district south of Bangkok) can be summarized as follow:

1. In the residential area at ONEB (Rams VI Road), the average concentration of SO_2 is 0.01- 0.08 mg/cu.m., and the highest value was 0.20. In the industrial area of Rat Burana (the other side of the river the average is 0.02 - 0.14 and the maximum was observed at 0.25 mg/cu.m. This pollutant was never found to violate ambient air quality standards of US.EPA or Thailand. In Samut Prakarn, where 2,500 factories operate, the yearly average from five stations was only 0.01 mg/cu.m. with the maximum of 0.20 mg/cu.m. This is explained by the high stacks which disperse the pollutant better. So even though the factories burn more sulfur in the fuels, the effect on ground level is less than the emission from motor vehicles.

2. There is no SO_2 monitoring at the curbside in Bangkok, except very few amount of data, as SO_2 has not been regarded as important pollutant in the city, so most of the monitoring efforts has been applied to the industrial

areas. The few data available for curbsides in Bangkok indicate 0.04 0.05 mg/cu.m. concentrations at Rama VI Road and the Victory Monument, which is low. The policemen and professional drivers who work in the streets may be at risk as the particulate matter is already very high (many times standards) and thus even a low concentration of SO_2 can cause increased respiratory symptoms. The sulfur dioxide may be the only pollutant that must be controlled not because it exceeds its own standards, but because its co-pollutant (particulate matter) is so high that even a small amount of SO_2 can be detrimental to human health.

- **Other Pollutants**

The nitrogen dioxide and ozone levels in Bangkok have not been determined extensively. Both pollutants are very expensive to monitor and they are considered to be secondary pollutants (both are formed from hydrocarbons and nitrogen oxide emitted from vehicles, in the presence of sunlight and mixing). Thus their formation is very complex.

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TRANSPORT AND ITS ENERGY-RELATED AIR POLLUTION PROBLEMS IN BANGKOK

By Naree Boontherawara, Sangsant Panich and Kunchit Phiu-Nual

Centralisation of Economic Activity and Traffic Congestion in Bangkok

Over the last three decades Thailand has pursued a development path based on industralisation with considerable success. Economic growth rates during this period have averaged over 5%; and, during the latter half of the 1980s, the real Gross Domestic Product (GDP) of the Kingdom grew by almost 10 percent annually. Thailand is thus emerging as a "Newly-Industlialised Country" after the model of Taiwan, Hong Kong, Singapore and Korea.

The industrialization of the last three decades has been highly centralized, however. The majority of industrial production, and of all economic activity has been concentrated in the Bangkok Metropolitan Region (BMR)[1]. More than 40 % of the nation's output comes from this region. About 70% of total industrial output and half of the value-added in other sectors as well as the services sector are also generated in this region. Neither is the picture expected to change much in the near future. Over the next twelve years, the BMR is expected to continue producing about half of the country's economic output and will

[1] The BNIR consists of the Bangkok Metropolitan Area (BMA) and its surrounding provinces: Pathum Thani, Nonthaburi, Samut Prakam, Samut Sakhon and Nakhon Pathom. The BMR covers a total area of 7,817 km^2

contribute a significant share of industrial and services sector output (NESDB undated; Table 1).

As the center of economic activity, the BMR has attracted people from all over the country. Better job opportunities and higher wages are major factors for drawing more migrants into the region. Population growth in the BMR averaged 2.1 percent during the period 1981 -1991, much higher than the national average of 1.8 percent. This high growth rate mainly reflects the large number of rural migrants who have come to the city in search of better economic opportunities. Population growth, however, has been oerbsved to occur at a faster rate in the neighboring provinces in the BMRI than in the central Bangkok Metropolitan Area. With a wide disparity in incomes between the capital and the rest of the country, this growth pattern is projected to continue through to the year 2001 (Table 2).

Table 1. Gross Domestic Product (GDP) and Share of Each Province and BMR to Total GDP (in Billion Baht, 1972 prices)

Table 1: **Gross Domestic Product (GDP) and Share of Each Province and BMR to Total GDP (in Billion Baht, 1972 prices)**

REGION	YEAR					
	1981	1985	1990	1996	2001	2006
WHOLE KINGDOM	318.4	394.1	631.8	1,020.8	1,491.6	2,093.0
	(100.0)	*(100.0)*	*(100.0)*	*(100.0)*	*(100.0)*	*(100.0)*
BMR	137.5	168.3	302.8	504.5	746.7	1,064.0
	(43.2)	*(42.7)*	*(47.9)*	*(49.4)*	*(50.1)*	*(50.8)*
BMA	107.3	129.2	227.4	375.3	551.0	779.9
	(33.7)	*(32.8)*	*(36.0)*	*(36.8)*	*(36.9)*	*(37.3)*
SAMUT PRAKAN	12.9	14.9	31.9	53.3	79.2	114.3
	(4.05)	*(3.78)*	*(5.05)*	*(5.22)*	*(5.31)*	*(5.46)*
PATHUM THANI	5.9	8.7	15.3	28.0	44.2	65.8
	(1.9)	*(2.2)*	*(2.4)*	*(2.7)*	*(3.0)*	*(3.1)*
SAMUT SAKHON	2.8	4.6	8.8	15.5	24.1	35.3
	(0.9)	*(1.2)*	*(1.4)*	*(1.5)*	*(1.6)*	*(1.7)*
NAKHON PATHOM	4.0	5.4	7.8	13.1	19.7	28.1
	(1.3)	*(1.4)*	*(1.2)*	*(1.3)*	*(1.3)*	*(1.3)*
NONTHABURI	4.5	5.5	11.7	19.3	28.6	40.6
	(1.4)	*(1.4)*	*(1.9)*	*(1.9)*	*(1.9)*	*(1.9)*

Source: Thailand Development Research Institute, Macroeconomics Program, 1994

Table 2. Population and Rate of Growth 1981, 1991 and 2001

Province	Population (thousand)			Avg. Annual RateGrowth (%)	
	1981	1991	2001	1981-1991	1991-2001
BMA	5,331	6,267	7,233	*1.6*	*1.4*
Samut Prakan	557	826	1,095	*4.0*	*2.9*
Nonthaburi	404	633	876	*4.6*	*3.3*
Pathum Thani	332	454	594	*3.2*	*2.7*
Samut Sakhon	271	343	425	*2.4*	*2.2*
Nakhon Pathom	570	632	755	*1.0*	*1.8*
Total BMR	7,465	9,155	10,979	*2.1*	*1.8*
Total Thailand	47,652	56,924	64,876	*1.8*	*1.3*

Source: The 1991 and 2001 population projections were obtained from the National Economic and Social Development Board (NESDB) and Thailand Development Research Institute (TDRI), respectively.

Unfortunately, urban growth has been largely unplanned and unregulated following a classic pattern of ribbon development along the major thoroughways. Consequently, Bangkok is currently experiencing serious physical infrastructure bottlenecks, most notably with regard to transportation. The inadequate road infrastructure is unable to absorb the city's rapidly growing vehicle population resulting in road congestion. The lack of a viable mass transport system option has further exacerbated traffic congestion as people rely more on their private vehicles. Since 1979, the traffic volume in the BMA has increased from 610,404 registered vehicles, to more than 2.7 million in 1993 with 51 percent (of the 2.7 mn) being personal cars, 42 percent motorcycles (mostly 2-stroke), 5 percent trucks and buses, and 2 percent taxis and three-wheelers (tuk-tuks).

More transport results in more fuel burned and higher levels of vehicle exhaust emissions released into the atmosphere. Like many other megacities in the world, therefore, Bangkok has serious air pollution problems associated with traffic congestion. Critical pollutants are lead, carbon monoxide, carbon dioxide, nitrogen oxides, hydrocarbons and suspended particulate maker. While all these pollutants have global and regional implications as well as local effects, the immediate concern of this paper is to consider options to address problems associated with air pollution at the local level.

Vehicle-related Air Pollution in Bangkok

Different vehicle groups cause different air pollution problems. Gasoline vehicles produce carbon monoxide; diesel vehicles produce black smoke and oxides of nitrogen; and two stroke engines produce white smoke and hydrocarbons (as major pollutants). Lead is emitted from vehicles using leaded gasoline. Air pollution was measured at 16 curbside monitoring stations in Bangkok in 1993 in order to measure the concentrations of carbon monoxide (CO), suspended particulate matter (SPM) and lead (Pb). As shown in Table 3, the concentration of SPM and CO in key sites around Bangkok is well above the threshold level at which they are believed harmful for human health. Ambient standards shown in the table compare current standards with those recommended by the World Bank and the Pollution Control Department in a study conducted in 1993. The health impacts of the pollutants of major concern are summarised below[2]:

- ***Lead***

Lead, released from leaded gasoline, is considered toxic to human health, as it can produce anemia at concentrations above 40 microgram/100cc. of blood (Office of National Environment Board (1981)Criteria for Air Quality Standards: Lead (mimeographed document)) and hypertension. Lead can destroy red blood cell corpuscles and affect the nervous system, especially in children.

[2] Carbon dioxide has limited health effects, and is of major concern because of its contribution to global manning it is, therefore, not considered in this section.

- ***Carbon Monoxide (CO)***

Carbon monoxide, a colourless and odourless gas emitted mainly because of the incomplete combustion in gasoline engines, can cause major health effects through its ability to combine with haemoglobin in the blood (forming carboxyhaemoglobin) competing with oxygen for the same sites. Carbon monoxide has a higher affinity for haemoglobin than oxygen, and also tends to remain more tightly bound. If high levels of exposure to CO continue for an extended period of time it causes headaches and lassitude. In addition, a small dose can result in the impairment of vision and time interval discrimination, and physiological stress in patients with heart diseases. Carbon monoxide is highly toxic at concentrations in excess of 1000 ppm. Death results from asphyxiation since body tissues, especially the brain, are deprived of an adequate oxygen supply.

- ***Hydrocarbons***

The health effects of hydrocarbons vary with type. Polycyclic aromatic hydrocarbons are believed to be potentially carcinogenic, but the mechanisms are little understood and not yet proven. Certain hydrocarbons are toxic at quite low concentrations, and many of the aromatics cause dizziness when inhaled for long periods. Hydrocarbon derivatives such as HCHO, acrolein, and peroxyl rutrate (PAN) are eye irritants commonly found in photochemical and other smogs.

- ***Nitrogen Oxides***

Nitrogen oxide is a relatively non-irritating gas, but is rapidly oxidized to $N0_2$ which is far more toxic $N0_2$ penetrates deep into the lungs where tissue damage may occur.

Table 3. Ambient air concentration in 16 curbside stations

STATIONS	Max TSP (24 hr) (μg/cu.m)	Max Pb (24 hr.) (μg/cu.m)	Max CO (8 hr) (mg/cu.m)	2ND High CO(8 hr) (mg/cu.m)
1. Pratoonam	1,530	1.02	9.10	8.84
2. Yaovaraj	860	0.98	11.39	10.58
3. Laniuang	450	0.59	-	-
4. Banglampoo	400	0.61	11.57	11.27
5. Sapankwai	410	0.59	11.43	10.93
6. Silom	500	0.67	15.50	15.29
7. Si Praya	-	-	8.00	7.85
8. Huamark	1110	1.66	18.93	18.72
9. Rama I	600	0.54	9.89	9.68
10. Bangkhen	410	0.33	11.26	11.12
11. Prannok	750	0.51	20.35	19.61
12. Charansanidwong	460	0.51	15.19	11.32
13. Ban Sondej	800	1.14	17.64	17.48
14. Phrayathai	540	0.48	10.10	9.96
15. Taksin	330	0.24	-	-
16. Samsen	460	0.15	-	-
Standard	330	10.00	20.00	20.00
Proposed standards[3]	330	1.25	10.00	10.00

Source: Department of Pollution Control. 1994. Personal Communication.

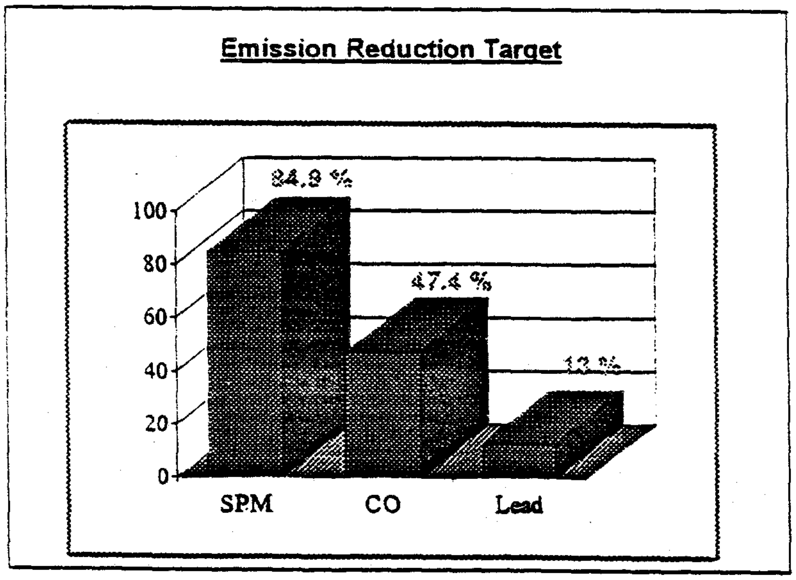
• Suspended Particulate Matter (SPM)

The health effects of suspended particulate matter depend on the size of the particle. Smaller particles are more harmful than bigger particles as they permeate the respiratory system and cause respiratory diseases. Moreover, suspended particulate matter found in many big cities has been found to have adsorbed Polycyclic Aromatic Hydrocarbons (PAH) which are believed to be associated with cancer. This has, however, not been proven. Smaller particles may also adsorb acidic compounds such as nitric and sulphuric acid (both present in the atmosphere of some cities) and carry them deep into the lungs.

The 1993 ambient air monitoring data, obtained from these stations mostly exceeded the proposed ambient air quality standards, especially CO and SPM. For SPM, it can be seen that 13 out of 15 stations violated the proposed/existing standards of 330 μg/m3. For CO ten out of 13 stations reported violations of the proposed ambient air quality standard of 10 mg/m3. According to the 1993 monitoring data, atmospheric lead concentration from automobiles did not present a serious problem, however. Ambient data from only 1station violated the proposed standard of 1.25 $\mu g/m^3$. This is because there have been many efforts in the past to reduce lead concentrations in gasoline, including initial reductions from 0.84 g/l of gasoline to 0.45 g/l in 1984, and subsequently to 0.15 g/l in 1992. Further, premium unleaded gasoline was introduction in 1991. At present, premium unleaded gasoline has captured about 40 percent of the market share for premium gasoline in Bangkok.

Objective of the Study

In order to achieve the air quality standards proposed by the Department of Pollution Control and the World Bank in 1993 (carbon monoxide at 10 mg/cu.m, lead at 1.25 ug/cu.m, and 10-micron particles at 100 ug/cu.m the following reductions in emissions must be achieved:



The Thai government has taken some steps to deal with air pollution associated with transport by implementing several regulatory measures including traffic and technology measures[3]. In addition, there are several traffic schemes to which the government is committed but which have not yet been implemented. There remain concerns about the effectiveness of these measures, however, in particular, because of the likely increase in road traffic in the future.

The objective of this study, therefore, is to examine and evaluate the effectiveness of the existing and planned measures in reducing the ambient level to, or below, the threshold level reflected in the proposed standards. These standards are used as indicators of health impact. A Scenario Approach is used in the study such that the effectiveness of a range of measures may be considered including measures which have not yet been agreed to by the government.

First, however, an overview of the Bangkok Transport System is given, together with the health effects of air pollution in Bangkok.

The Bangkok Transport System: An Overview

Transport in Bangkok is dominated by road traffic. The Bangkok road network consists of several major arterial roads, many minor roads, and smaller local access roads, or *"sois"*. Total road surface represents about 10.7 percent of the city's total land area. However, according to JICA (1990), the road network in Bangkok suffers various shortcomings due to poor quality construction, and the unclear or improperly defined hierarchical structure of the roads. The most critical problem is the deficiency of secondary distribution roads and missing links between road networks.

Public transport is dominated by buses which operate mainly on the city's major roads The bus system comprises about fourteen thousand buses operating on 293 lines. There is no

[3] Examples include the regulations on lead content, and restrictions on engine performance and emissions on new vehicles.

systematic routing of the buses, rather existing routes have been used and modified for at least the past thirty years. This has resulted in very long bus routes and inconvenient connections between routes. Other public transportation is provided by taxis, tuk-tuk (three wheel motorized rickshaws, using two stroke engines with LPG) and motorcycles. Motorcycles for hire are in operation in sois (lanes) only.

The BMA does not have a rapid transit system at present. Construction of a mass transit system was first discussed in 1973. Although a study plan was completed in 1981, implementation has been delayed until the 1990s. This delay has caused severe traffic congestion as rapidly growing demand for motorized travel far exceeds the capacity of the existing road network and public transport system. At present, three proposals for mass transit systems have been formalized into contracts including Tanayong or Bangkok Transit System Corporation (BTSC), the Hopewell project and the skytrain project. Table 4 summarizes the basic features of the three Mass Transit Systems.

Table 4. Basic Features of Three Mass Transit Systems in Bangkok

Table 4: Basic Features of Three Mass Transit Systems in Bangkok

System	Tanayong	Skytrain	Hopewell (Ext. Rail)	Hopewell (Com. Rail)
Number of bogies	3	6	15-20	12
Width of rail area (meters)	8.3	8.3	26-34	26-34
Passengers/train	800-1,000	1,200	6,000	3,600
Passengers/hour/direction	25,000	40,000	20,000	60,000
Number of rails	2	2	2-3	2
Rail width (meters)	1.43	1.43	1	1.43
Distance	14.5	20	60.1	60.1
Distance between stations (meters)	800	1,000	3,000-7,000	700-1,200
Maximum speed (km/hr)	80	80	80	90
Average speed (km/hr)	20-25	30-40	30-40	40-60
Responsible agency	BMA	MRTA	SRT	SRT
Investor	Tanayong	Government	Hopewell	Hopewell
Investment (million bath)	20,000	36,500	80,000 1/	

1/ Including the costs of express way and land development schemes.

According to the surveys conducted by the Mass Rapid Transit Authority in 1993 on trips taken within the major business areas of Bangkok, the average trip length is approximately 5 kilometers. It is expected that bus riders will use the subway or elevated train service if available for these trips. However, it is not expected that the mass transit systems will significantly alleviate traffic congestion as the majority of private car owners will probably continue to rely on private transport[4].

Given the current condition of public transport systems in Bangkok, it is not surprising that those Bangkok residents who can afford it prefer to use private vehicles, taxis and motorcycles. The annual growth of private vehicles is approximately 9.5% (NEPO, 1992) while vehicles are scrapped at a rate of less than 1.5%. At the same time, the construction of new roads in the past ten years has been negligible due to high land prices. Unsurprisingly, therefore, the most prominent characteristic of Bangkok's current transportation system is traffic congestion.

Growth in Bangkok's vehicle fleet has risen sharply over the past decade with almost no regulations aimed at restricting or limiting the fleet size. The average annual growth in vehicle-kilometer (V-Km) for the country is approximately 10 percent over the period of 1982-1990, while the annual growth of road space is approximated to be less than one percent per year. The average speed in the city center is around 10 kilometers per hour. The travel speed in the area between Ratchadapisek Ring Road and Outer Bangkok Ring Road averaged to be 34.7 km/hr and the minimum speed was 17.5 km/hr (SEATEC, 1993).

[4] Urban sprawl in Bangkok makes it difficult to plan and construct an effective fixed rail system in a short period of time. Judging from the proposed mass transit projects, these systems will not link outer-lying disctricts of Bangkok (which contain large residential centres) with the city centre. Therefore, private passenger cars are likely to remain essential for a substantial proprotion of the population.

Different vehicle groups emit different pollutants. More than 80 percent of motorcycles have two-stroke engines which emit more hydrocarbon than those of the four-stroke ones. Trucks and buses constitute 4.5 percent of the BMA's fleet. Taxis and tuk-tuks (samlors) make up 1.5 of the Bangkok's fleet.

Factors Contributing to Air pollution Associated with Transport Sector in Bangkok

Urban sprawl, economic and population growth have produced a situation where more and more people are driving greater distances to work and home. Both personal transport and freight transport are mostly met via road transport. The inadequate capacity of the road network system to support this growing transport demand leads to ***traffic congestion***. Slow speeds, frequent stops, rapid deceleration and acceleration all result in a greater incidence of incomplete combustion in the engine and hence higher emissions.

- Fuel Quality

Fuel quality plays a significant role in urban atmospheric conditions. Since emissions vary with the specifications of fuel used in the transport sector, improved fuel quality could help reduce overall emissions. For example, the introduction of unleaded gasoline in May 1991 and the reduction of lead content in gasoline from 0.4 grams/liter to 0.15 grams/liter in September 1992 has helped to reduce lead emissions from vehicle exhaust. Lead free gasoline is expected to become mandatory for all grades of fuel by 1996.

Diesel fuel quality has been improved by lowering its sulfur content. This has contributed to the reduction of sulfur dioxide emission and sulfates that result in suspended particulate matter concentrations. Use of low-sulfur diesel (0.5 percent weight as opposed to 1.0 percent) was made mandatory in September 1993. A plan to further reduce sulfur content to 0.25 percent by weight in 1995 and 0.05 percent by weight in 2000 is under consideration. In addition, the Thai government has mandated lowering the distillation temperature of diesel fuel at 90 percent from 370 degree to 357 degree celcious so as to reduce black smoke emissions.

- **Vehicle Fleet Composition**

Different type of vehicles consuming different fuel type emit different levels of pollutants. Overall vehicular emissions depend heavily on vehicle technology as well as fuel quality. According to the registration record of the year 1990, 57 percent of total registered vehicles is personal cars, 35 percent is motorcycle in which about 82 percent is 2-stroke motorcycles, and approximately 4 percent is buses and lorry. Diesel-powered vehicles, largely trucks and buses, contribute large amounts of NOx and SO_2. Motorcycles emit significant levels of hydrocarbons, lead and particulates. Personal cars are major contributors of CO, HC and lead. Taxis and Tuk-tuks use LPG which emit less of CO, CO_2, NOx and Sox. The new fleet of 29,000 metered taxis in 1994 is replacing the 16,000 non-metered taxis. It is estimated that about 50 percent of the existing taxi fleet uses LPG.

- **Vehicle Maintenance**

Vehicle maintenance can greatly affect emission levels of all types of vehicles. Well-maintained vehicles emit less of HC, CO and NOx compared to the poor-maintained vehicles. The inspection and maintenance (I/M) program can be effective in lowering emissions in two ways:

- By lowering emissions from vehicles which fail the test and are required to be repaired

- By encouraging owners of vehicles to take proper care of them and to avoid the potential costs of repairing vehicles which have been tampered with or misfueled.

It is estimated that a well run I/M program is capable of very significant emissions reductions, on the order of 25 percent for HC and CO and about 10 percent of NOx (Walsh, M. et al, 1992).

Currently, noise and emission testing are required and are conducted under the Land Transport Department's (LTD's) general vehicle inspection program. All new vehicles are subject to such inspection. For in-use vehicles, only those registered under the Land Transport Act (buses and heavyduty trucks) and commercial vehicles registered under the Motor Vehicles Act (taxis, tuk-tuks and rental vehicles) are subject to inspection during annual registration renewals. It is expected that Land Transport Department will require all in-use vehicles to be inspected, starting in July, 1994. Vehicles, being used for ten or more years, are subject to an annual inspection while the newer vehicles will be subject to inspection at different time periods[5]. This will be determined by the LTD. Private inspection centers are being licensed.

- Vehicle Standards

The Industrial Standard Institute (TISI) of the Ministry of Industry has adopted ECE83 type-approval standards for all gasoline cars sold in 1993 and is expected to impose tighter standards on cars in the near future. Motorcycles, light and heavy duty vehicles will be subject to the type-approval standards in the near future.

For the in-use vehicles, the standards for CO emissions are currently set at 6 percent at idle. This standard is expected to be changed in mid-1994 to 4.5 percent for pre-1993

[5] The World Bank is supporting the LTD in the development of an I/M Program.

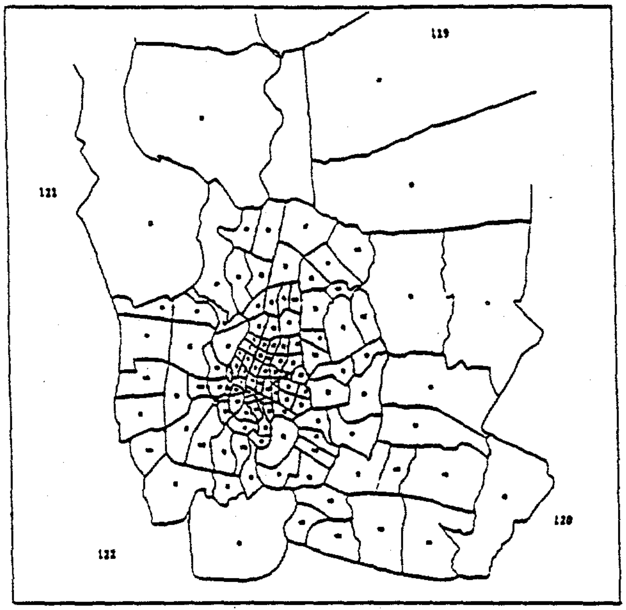
models and 1.5 percent for later models. Hydrocarbon standards will also be specified at 600 and 200 ppm respectively. Black smoke standard is now 50 percent based on Bosch type filter method (the change to opacity measaurement is under DPC's review). Hydrocarbons from motorcycles are currently set at 14,000 ppm which will be lowered to 10,000 ppm later.

Air Pollution Study "Traffic Crisis and Air Pollution: A Case of Bangkok"

The study area covers the BMA, and Nonthaburi, Samut Prakan and Pratumtllalli provinces in the BMR. This study area was divided into 118 traffic zones and 4 outside zones (see Figure 1). Road networks for the base year (i.e. 1994) included primary and secondary distribution roads. Some small and short distribution roads and local roads(sois) were left out since these were within the traffic zone and the traffic problems on these roads did not accurately reflect the urban traffic area.

Since the study involves an evaluation of measures which are being implemented or have been planned for the year 2000, a scenario approach is undertaken. Three traffic scenarios as well as three technology scenarios (see Appendix A for details description of scenarios) are formulated for the purpose of policy evaluation.

Figure 1. Traffic Zone in the Study Area



Traffic scenarios consist of ***Do-Nothing,*** uses the 1994 road network with no improvement but with the trip matrix projected for the year 2000; ***Do-As-Committed,*** assumes planned measures are implemented for the year 2000; and ***Demand-Management,*** includes the measures implemented under the Do-As-Committed Scenario plus three major restraint measures - physical, quota, and pricing restraints with some bus transport improvement. In addition, technology scenarios are evaluated assessing the effects of implementation of Base Case, Reasonable and Best Technology Scenarios. ***Base Case Technology Scenario (BASE)*** represents a control scenario incorporating current and planned future control strategies. The ***Reasonable Technology Scenario (RT)*** builds on the base case by adding controls on vehicles and fuels, and also by introducing a relevant inspection and maintenance (I/M) program. It is a control scenario describing control technologies which are reasonably possible to implement in the future year.

In particular, assessment of reasonable technology is based on: evaporative controls in 1997; an effective I/M program, using stringent emission standards; only unleaded fuels from 1996; and the use of ECE 91/441 standard[6] in 1996 for light duty gasoline trucks. Finally, the ***Best Technology Scenario (BT)*** is a more aggressive technology scenario for implementing maximum control technologies in the future. It involves additional improvements in new vehicles' standards, further advances in the I/M program and anti-tampering efforts, and improvements in conventional fuels. In particular, the case of BT requires motorcycles to use the proposed Taiwan Standard (2.5HC+NOx) in 2001, and move the I/M program to 1996.

The technology and traffic scenarios described in Appendix A are combined to assess the impacts of existing and planned measured of the future year with the proposed standards used as evaluation criteria as shown in table 5.

Table 5. Policy Scenarios for the year 2000

Traffic Scenarios	Technology Scenarios		
	1. Base Case Technology	2. Reasonable Technology (RT)	3. Best Technology (BT)
1. Do-Nothing Scenario	1994 road network and Base Case technology	1994 road network and Reasonable Technology	1994 road network and Best Technology
2. Do-As-Committed Scenario	2000 road network + committed planned to be completed by 2000 and Base Case technology	2000 road network + committed planned to be completed by 2000 and RT	2000 road network + committed planned to be completed by 2000 and BT
3. Policy Scenario (Do-As-Committed plus supplementary traffic measures)	2000 road network + committed planned to be completed by 2000+ supplementary measures* and Base Case technology	2000 road network + committed plan to be completed by 2000+ supplementary measures and RT	2000 road network + committed plan to be completed by 2000 + supplementary measures and BT

* Supplementary measures as given in the Traffic scenario under Demand-Management-Policy scenario.

[6] ECE refers to the European Community Type Performance Standards, which is applicable for new cars or other vehicles to be sold in that particular year.

Mathematical Models

The study used three mathematical modeling procedures in the simulation exercise to estimate ambient air quality/concentration in the study area for the year 2000:

1. Transport Modeling
2. Emission Factor Modeling
3. Dispersion Modeling

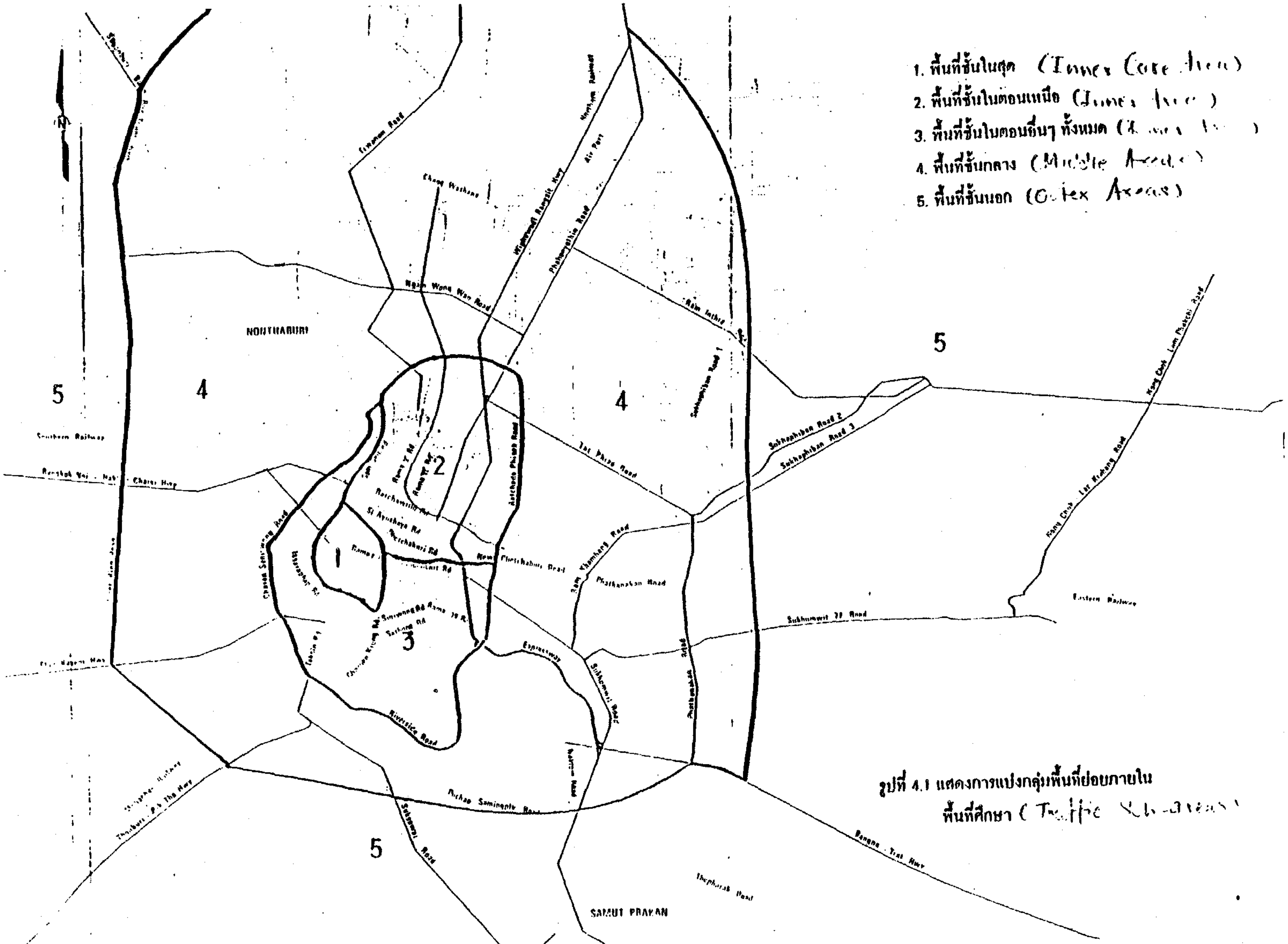
1. Transport Modeling

This model was used to define transportation characteristics suitable to input into the air pollution models in order to compute emission loads and ambient air pollution. The model simulated the traffic condition of the study area for the base year (1994) and the future year (2000). Travel demand was forecast and assigned to various predetermined road networks (link nodes) from the study area. The other outputs of traffic volume, traffic speed, fleet composition and characteristics were used as inputs for the other two models, i.e. the emission factor and dispersion models. In this study, a conventional sequential transportation model has been employed. This model can be divided into 2 parts: demand models and network models.

Demand Models

The main objective of the model is to compute total trips within the study area. The trips are in person trips. These person trips were then converted to vehicle trips and assigned on the road network or on other networks. For each traffic zone, five kinds of socio-economic data were gathered and reviewed: (1) population; (2) number of schools and students; (3) income; (4) employment opportunities; (5) car and motorcycle ownership. Some land use data were also reviewed such as total land use area, available plots and the character and intensity of land use activity. This data was then used to formlulate trip generation and attraction models. The results of these models and the network analysis were calibrated against trip rate per person. The final result was a trip end table explaining the total number of trip generated/attracted in each zone. These trip ends were distributed using a trip interchange/distnbution model.

The model was started with the computation of average trip length and trip length distribution from the former trip matrix. Then the shortest route cost for all zones was computed from the network. The data including trip end data was inputed into the trip distribution model in order to derive a trip interchange pattern for the study area. Results of the process are trip matrices classified by purposes. These matrices were later combined to calculate the total person trip matrix.



รูปที่ 4.1 แสดงการแบ่งกลุ่มพื้นที่ย่อยภายใน
พื้นที่ศึกษา (Traffic Sub-areas)

The Road Network Model

Road networks, were formulated from the former road network model compiled by the Pollution Control Department. Most of the main roads and the selected collectors were included and the total link distance in the study area was about 2,435 km. On each link, there were four types of accompanying data: the speed-flow relationship, hourly expansion factors, vehicle composition factors, and road group factors. These factors were used to expand the peak hour volume resulting from traffic assignment[7] to all necessary data such as average daily traffic volume, average hourly volume for the specific hour, average speed, vehicle composition for the corresponding volume and finally, number of motorcycles, to be input into the environment models for the base-line and future study. From this data, the study team estimated future year/yearly trip ends for the year 2000, and carried on to estimate trip distribution, mode choice and finally traffic assignments.

Results

This section summarizes the traffic condition results obtained from the transport model fro the base year and the future year. The main results of the traffic study can be roughly divided into two parts: a) the traffic situation for the whole area or sub-area and, b) traffic volume, speed, time and volume/capacity ratio on all links. The study team forecast future traffic conditions for the three traffic scenaroos mentioned previously in addition to that of the year 1994. Traffic speeds for the 5 sub-areas are summarised in Tables 6 and 7.

[7] Traffic assignment is a process used to derive traffic volume, especially peak hour volume, from the trip matrices as derived earlier in the demand model study. Firstly, all the person trip matrices were converted to vehicle trip matrices by applying occupancy factors; then vehicle trip matrices were converted to passenger car (PC) matrices and added up to a peak hour PC matrix. Finally. the matrix was assigned to the network by using incremental assignments (10 increments).

Table 6. Average speed and Vehicle-Kilometers, 1994

Traffic Zone	Average Speed (km./hr.)	Vehicle-Kilometers during peak hour (Unit: thousand km.)
Inner Core Area	10.8	76.1
Inner Area	19.2	314.3
	20.5	1,102.4
Middle Area	27.6	2,606.6
Outer Area	37.7	249.2
Express Way	22.8	32.3 †

Table 7. Traffic Condition for the Year 2000

Traffic Zone	Case I: DoNothing		Case II: 2000 Do-As-Committed		Case III: 2000 Policy	
	Speed (km./hr.)	Vehicle-Kilometers (Unit: 1000 km.)	Speed (km./hr.)	Vehicle-Kilometers (Unit: 1000 km.)	Speed (km./hr.)	Vehicle-Kilometers (Unit: 1000 km.)
Inner Core Area	10.80	75.70	11.80	71.90	15.70	62.80
Inner Area	15.00	339.80	16.70	340.80	16.20	270.30
	21.50	1,241.70	22.20	1,088.00	21.70	987.50
Middle Area	24.20	3,066.90	25.00	3,174.80	28.80	2,589.70
Outer Area	28.00	268.30	35.90	260.90	46.00	232.40
Express Way	23.70	32.80	23.50	31.30	30.50	28.90

The situation for 1994 can be summarized as follows: Traffic speed in the inner area was very slow with the average speed being about 10 km/hr. while traffic speed for outside areas were about 20-30 km/hr. Speed on some links (i.e. road sections) was as high as 60 km/hr, but some sections were as low as 9 km/hr. showing high speed variation which can also be a major problem, since travellers are unable to estimate travel time along major roads.

For the future year, under the ***Do-Nothing Scenario*** the speed of traffic within the inner area inner area 1) has not been reduced at all, while the traffic speed for the other areas has been declining. This is because traffic in the inner area 1 is already at peak capacity and thus, even if there were demand for more capacity, the network (1994 road network) is not able to accept any more traffic. In the middle areas, on the other hand, the network is still able to accept more traffic which results in greater congestion and hence lower traffic speed. For the outer area the situation shows a more significant decline in traffic speed, since the network's capacity is less than the increasing demand. While on some days traffic may move at 20 km/hr, on other days speed may be reduced to as low as 5 km/hr.

While speed was slow in all areas, speed variation (i.e. average speed for all areas) was as high as 200 percent. This situation indicated an unstable traffic condition. While on some days traffic may move at 20 km/hr, on other days speed may be reduced to as low as 5 km/hr.

For the ***Do-As-Comntitted Scenario***, there were 3 major improvements to the existing network by the year 2000 - more roads and expressways, new mass rapid transit systems, and new truck terminals within the study area. The mass rapid transit (MRT) system affects the demand for private cars along the new MRT corridors. This was calculated by applying the modal split model to trip interchanges among these zones. It was assumed that there will be no bus transport along the corridors (this is always stated in all MRT concession contracts for Bangkok), therefore bus value (V bus) for the modal split model was switched to MRT value and used to compute travel choice for MRT. The demand for movement in this area was also adjusted to include "latent demand".

Traffic speed in the inner area improved by about 10 percent as a result of the new MRT system. Traffic speed in other areas however, did not improve at all. Travel distance was also longer due to more available road space. Vehicle hours were much higher as more cars would be on the road, and commuters would also still be dependent on passenger cars.

For this scenario, the demand for travel was so high that even the three new mass transit systems, the newly planned expressway, the major and minor roads and the new terminal, in addition to the existing network could not accommodate this demand. It is therefore necessary that some demand management measures are introduced in order to control or restrain this latent demand. Also some of the already suppressed demand should be accomodated by the public transport system.

For the ***Demand Management Policy Scenario***, the study team thus introduced four primary remedy measures: i) increasesinfuel prices; ii) provision of extensive busways within the middle and outer areas and improving the existing bus lanes within the inner area; iii) modifying traffic operation plans in inner areas so that buses can travel shorter distances and can receive priority treatment at most junctions; and finally, iv) introducing some simple traffic restraint projects: such as only allowing the use of cars with odd, or even, number plates on Ratchadapisak ring road on odd and even days, respectively. This traffic restraint measure would reduce passenger car traffic by about 30 percent. It is also assumed that the government will improve the existing school-bus service to the extent that about 50 percent of student trips as passengers in passenger cars will switch to use school buses. This scheme was also included for testing in the "suggested case for the year 2000".

Further, bus speeds were increased to about 25 km/hr in the outer area and in part of the middle area. Within the inner area the bus speeds were increased to 15 km/hr. Waiting time outside of bus time (i.e. walking or using other modes of transport and transfer) was reduced to about 50 per cent of the present, existing time. This is data was then applied to the multinomial logit model for all trip purposes, and new person trip matrices were computed.

School trips of students using private cars was further reduced to about 50 percent of the existing trips. After that the person trip matrices were converted to person car (PC) matrices and added up to derive the peak hour matrix. The matrix was then assigned to the network. Results of this first stage study showed that travel speed only increased between 5-10 percent. As a result, the use of odd and even number plates and area pricing (within Ratchadapisak ring road - i.e. RRR) was introduced by reducing the vehicle trip matrix to about 65 per cent of the year 2000's trip matrix (results from a study carried out in Lagos, Nigeria a few years ago and in Seoul, South Korea during the Olympic Games).[8] Area pricing was also tested by increasing the link cost for all road links entering and exiting within the RRR. Link costs were easily added by rewriting the generalized cost formula as:

Link Cost = a.time + b.distance + c where a, b and c are coefficients

C is always multiplied by a specific column in the link network (link class) which was specified at each entry and exit from the restraint area. Then traffic assignments were

[8] Phiu-Nusl Kunchit, 1993.

carried out for the network and the newly derived matrix, after introduction of the restraint measures.

All travel speeds for *all* the areas improved. Total vehicle travel distance was reduced significantly, to a satisfactory level. Average vehicle operating cost was reduced to almost half of the existing level which is close to the cost 15 years ago. Average vehicle journey speed was also increased to about the same as in other big cities in the world, such as London and Nagoya.

2. Emission Factor Modeling

In response to the serious air pollution threat to the citizens of Bangkok, the public and the government are pushing for a more aggressive pollution control effort. Thailand's current Seventh Plan has thus moved towards sustainable economic growth and development while enhancing the quality of the environment and natural resource base. A high priority has been placed on improving air quality and definite targets have been set to control the emissions of suspended particulate matter, carbon monoxide, and lead on Bangkok's major streets. These measures[9] were incorporated into the emission factor model, and their effects on air pollution evaluated.

[9] These measures include:

1. introduction of unleaded gasoline at prices below that of leaded gasoline (introduced in May 1991)
2. reduction of the maximum allowable lead in gasoline from 0.4 to 0.15 grams per liter (effective as of January I, 1992).
3. a plan to phase out leaded gasoline by 1996
4. reduction of the sulfur content of diesel fuel from 1.0 to 0.5 percent as of April 1992 in the Bangkok metropolitan Area and after September 1992 throughout the whole country; the use of low sulfur diesel fuel has been mandatory in Bangkok since September 1993.
5. reduction of the 90 percent distillation temperature of diesel fuel from 370 degrees C to 357 degrees as of April 1992 throughout the whole country.
6. required all new cars with engines larger than 1600 cc to meet the ECE R-83 standards after January 1993; all cars were required to comply after September 1, 1993.

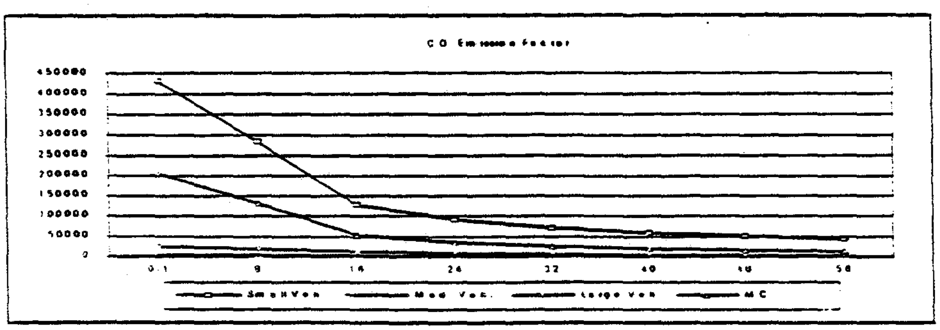
The emission factor model used is the MOBILE 5 model from the U.S. Environmental Protection Agency (U.S. EPA) as modified by Radian Corporation, U.S.A. for the Department of Pollution Control [10], in 1994. The model calculates the emission factors for pollutants in grammes per kilometre, with vehicles driven at different speeds for given vehicle types, and characteristics since vehicle exhaust emissions are dependent on factors including traffic speed, vehicle type, vehicle condition, type of fuel used, etc., it is therefore necessary to take these factors into consideration when computing the emissions of each vehicle type per distance travelled (i.e. the emission factor). The resulting emission factors from this model and the resulting traffic volume from the traffic model are then used to derive the emissions loads and the ambient air quality or pollutant concentrations for each link node in the dispersion model.

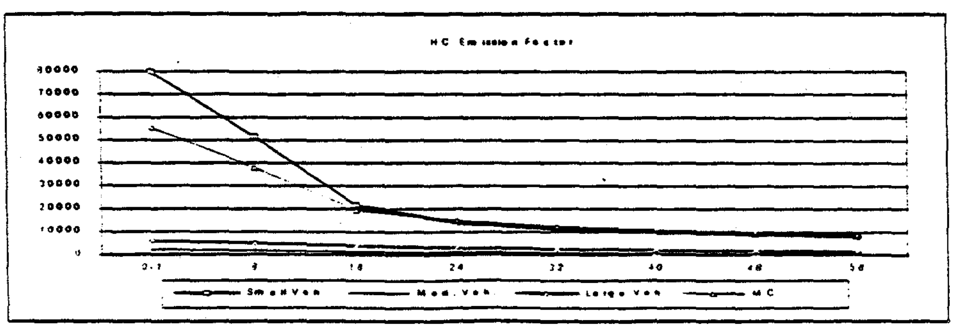
The primary components of the emission factor (MOBILE 5) model include the base emission factors, characterization of the vehicle fleet, fuel characteristics, vehicle operation conditions and the effect of local ambient conditions, alternative Inspection/ Maintentance programmes (I/M) and tampering and misfueling (see Appendix B). None of these factors remain constant: technology is continually evolving leading to changing in-use emission performance; changes in fuel prices and economic conditions leading to changes in vehicle sales and travel pattems, etc.

7. Taxis and Tuk-Tuks have already been largely converted to operate on LPG.
8. ECE R 40 requirements for motorcycles were introduced in August 1993 and followed soon afterward by EE R40. 01; the government has just decided on a third step of control which will be phased in starting in 1995.
9. ECE R49.01 standards for heavy duty diesel engine vehicles are now in effect.
Further investigations are underway to introduce more stringent standards for motorcycles as well as light and heavy trucks, and to purchase 200 CNG buses to reduce the smoke problem
[10] Pollution Control Department, 1994, "*Motor Vehicle Pollution Control in Bangkok: A Strategy for Progress,*" a draft report coauthored by Sandeep Wishan, Rob Klausmeier, Dr. Sangsant Panich and Michael P. Walsh.

In order to use the Mobile 5 emissions model, it must be customized to the conditions in the city for which it will be used. This is done by changing the computer code and input parameters to describe the conditions which are being modeled. These input files were used in Bangkok to describe the unique vehicle characteristics of the city (i.e. vehicle technology, mileage distribution by type, age distribution by type), typical operating characteristics (e.g., average speeds), ambient characteristics (e. g., temperature) and fuel characteristics (e.g. volatility). In addition, the basic emission rates and control strategies were modified to reflect the three different technology scenarios i.e. Base Case Scenano, Reasonable Case Scenario and Best Technology Scenario. Figure 3 illustrates the en emission factors for the fleet of vehicles in each category for 1993 with various average speed. Particulate emission factors were based on the output from a preliminary version of an EPA particulate model.

Figure 3. Emission factors for different category vehicle and speeds





3. Dispersion Modeling

The dispersion model used in this study is the AIRVIRO model (supplied to the Department of Pollution Control, Thailand, by the Swedish International Cooperation Agency (BITS)). Since the ambient levels depend largely on the meteorological condition of each area (link node), it is important to take wind speeds and wind directions into account when dealing with the dispersion of vehicle exhaust emissions for each link node. In addition, the surrounding environment, such as the concentration of tall buildings, plays an important role regarding how well the emissions can be dispersed into the atmosphere. For instance, a street surrounded by tall buildings, is likely to have a higher ambient concentration of pollutants than other, more open, streets. Likewise, it is expected that streets which generally have a higher wind speed and wind movement along the street, will have a higher ventilative capability and hence lower concentrations of pollutants.

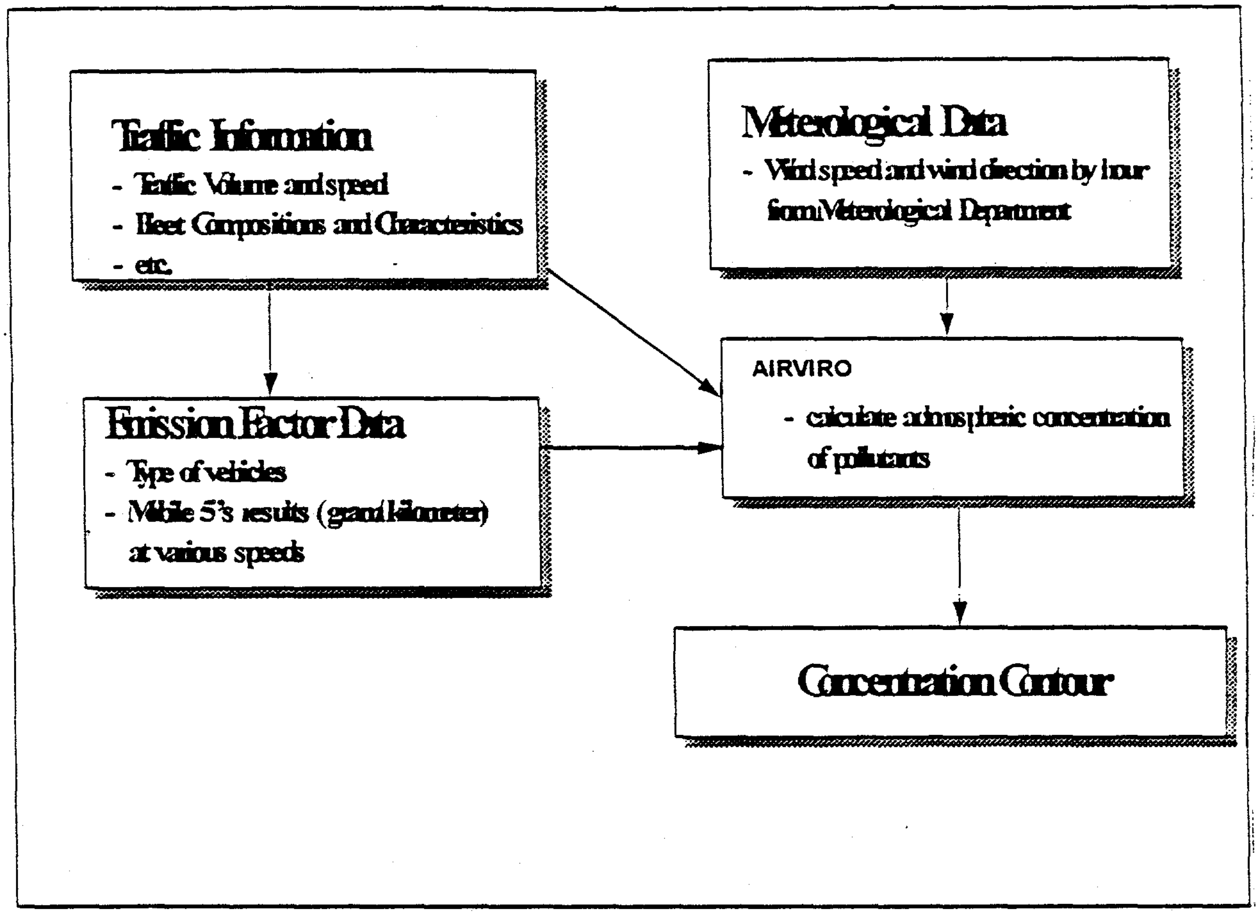
Linking the Models

Dispersion of pollutants was interlinked with the transport and emission models to produce a picture of the ambient concentration of key vehicle-related air pollutants in Bangkok in 1994 and in the future years. The following flowchart (Figure 4) shows how the three models interlink to estimate/forecast pollutant concentrations or ambient air qualtity for the study area. These estimates, obtained under various scenarios, will be compared to the proposed ambient air quality standards for the purpose of policy evaluation.

Results

Both the emission load and ambient concentration results are calculated using the AIRVIRO dispersion model which incorporates the results of both the traffic model and the emission factor model. The following section presents these results. This study looks at a macro picture of the CO and HC exhaust emissions for the whole study area. The ambient concentration on the other hand is done at the Macro scale level (street level) for CO and SPM[11]. For this scale, Rachprarop, Siphraya and Charunsanitwong are chosen to illustrate the air pollution problem of streets with congestion.

Figure 4. Linking the Models in the Study



[11] Please note that for SPM, the study limits its analysis to calculate SPM ambient concentration only from motorcycles which are one of the major emitters of SPM in the transport sector.

- Emission Load

The emissions impact of each scenario including the 1994 emission estimates for carbon monoxide and hydrocarbons is summarized in table 8. The 1994 emissions for CO and HC were found to be 2.31 and 0.49 million tons respectively.

The next case study is for the year 2000 under a Do-Nothing scenario. Here there is an increase of CO and HC to 2.58 and 0.57 million tons per year respectively (12 and 16 percent increase) due to the increase in traffic. For this case the increase/decrease in emissions is limited. This is because traffic congestion in 1994 with the present network will seriously restrict expansion of the vehicle fleet. For this particular case, if reasonable control technology is used for emission control, the CO emission will be reduced from 2.31 to 1.90 million tons in year 2000. Hydrocarbons produce similar trends. Use of the best technology will reduce HC and CO emissions further to 0.27 and 1.37 million tons respectively.

Table 8. Emission Loads (millions tons per year)

Traffic Scenarios	Technology Scenarios					
	Base Case Technology		Reasonable Technology		Best Technology	
	CO	HC	CO	HC	CO	HC
1994	2.31	0.49	-	-	-	-
2000 Do-Nothing	2.58	0.57	1.90	0.44	1.37	0.27
Do-As-Committed	2.87	0.63	2.06	0.49	1.50	0.32
Demand-Mgt.	1.54	0.34	1.13	0.27	0.83	0.18

With a Do-As-Committed traffic scenario, it is found that as traffic volumes increase with more roads, pollution loads also increase. For CO and HC, the emissions are 2.87 and 0.63 million tons per year. The result is not surprising as more roads mean more vehicles will be on the streets for a given time interval and hence higher emissions are expected. Using a reasonable control scenario the reduction of CO and HC from the base case technology will be 28 and 22 percent respectively. With the best technology option, CO and HC emissions will be further reduced by approximately 50 percent respectively with reference to the base case result.

For a Demand-Management Policy traffic scenario, there is a significant improvement on all emissions to 1.54 and 0.34 million tons per year for CO and HC respectively. This traffic scenario will reduce emissions of both CO and HC by (approximately) 45 percent across all technology options comparing to the Do-As-Committed scenario. If reasonable technology is used along with the Demand Management Policy scenario, they can be further reduced by 61 and 57 percent for CO and HC respectively (from the Do-As-Committed under the reasonable teclnology option). Best technology scenario will reduce emissions further to 71 percent from the base case implemented under the Do-As-Committed traffic scenario.

In sum, for **carbon monoxide**, the application of *reasonable control technology* limits the growth of these emissions by more than half, while the application of the best technology, is estimated to actually reduce **particulate matter** significantly for motorcycles (This is for illustration for SPM emission load from motorcycles by assuming the average speed of 15km/hr). Hydrocarbons follow a pattern very similar to CO, i.e., the *reasonable control scenario* reduces the growth somewhat but does not prevent growth from occurring. The *best technology case* would, however, bring about a substantial reduction in hydrocarbon emissions.

- **Ambient Concentration**

The emission load results can be applied to section of roads, and the model can then be applied to determine the expected concentrations of pollutants. The model used in this study is the AIRVIRO street canyon model which was supplied by the Swedish International Cooperation Agency (BITS). The summary results are presented in table 9.

Table 9. Summary results of ambient concentrations under various scenarios

ROAD	CO (mg/m^3) (8-hour average)			SPM ($\mu g/m^3$) (1-hour average) Only for motorcycles		
I. Rachprarop	Base*	RT**	BT***	Base	RT	BT
i) *1994*	16	-	-	247	-	-
ii) *2000* Do-Nothing[a]	38	27	20	335	333	216
Do-As-committed[b]	19	14	10	270	270	175
Demand-Mgt.- Pol.[c]	12	9	7	220	215	140
II. Siphraya	Base	RT	BT	Base	RT	BT
i) *1994*	7	-	-	163	-	-
ii) *2000* Do-Nothing	11	8	6	223	218	141
Do-As-committed	4	3	2	102	99	65
Demand-Mgt.- Pol.	2	2	1	52	51	19
III. Charunsanitwong	Base	RT	BT	Base	RT	BT
i) *1994*	11	-	-	260	-	-
ii) *2000* Do-Nothing	13	10	7	285	281	192
Do-As-committed	12	9	6	275	270	183
Demand-Mgt.- Pol.	13	10	7	284	278	192

Note: *Base = Base Technology **RT = Reasonable Technology ***BT = Best Technology

a. Do Nothing = Traffic in the year 2000 with 1994 road networks

b. Do-AsCommitted = Traffic in the year 2000 with year 2000 road networks

c. Demand-Management Policy = Do-As-Committed plus new measures.

Table 9 shows the summary results of ambient concentration of CO and SPM under various scenarios during the morning peak hours of traffic. The ambient concentration are higher for the Do-Nothing traffic scenario where there is no improvement or expansion of existing road network from that of the 1994's. This is due to the increase in traffic in the year 2000. The 1994 CO ambient concentration of Rachprarop and Charunsanitwong already present pollution problems as the estimated ambient (which are very close to the monitoring data of the 1993) are above the proposed standard of 10 mg/m^3. The estimated ambient concentration for the year 2000 of the three streets is well above the threshold at which health impacts can be expected.

For Rachprarop, the best technology scenario must be implemented if no further action is taken to adopt additional traffic measures above those already planned for the year 2000. However, a reasonable technology scenario will be sufficient to achieve the proposed CO ambient standard if a "Demand-Management-Policy" traffic scenario will be simultaneously implemented. For Charunsanitwong road, it seems that the reasonable technology scenario must be implemented at the minimum in order to bring the ambient level of pollutants down to the proposed standard. Even though, the estimated SPM ambient concentrations do not violate the recommended standard of 330 ug/m^3, it should be noted that these estimates are calculated *only* for motorcycles. Higher concentrations are therefore expected if other vehicle types including trucks which are also major emitters of SPM were included in the analysis. It is therefore difficult to draw any conclusion with respect to the effectiveness of various policy scenarios. Moreover, dust also originates from other sources, it is therefore recommended that dust from other sources be controlled if the SPM problem is to be addressed effectively.

Conclusions

Suspended Particulate Matter (SPM) is a major pollutant, followed by carbon monoxide and lead, as the ambient levels of these pollutants all exceed international standards such as those laid down by the World Health Organization (WHO). In order to meet these standards, it is necessary to reduce the emissions of these pollutants by 84.9 percent, 47.4 percent and 13.0 percent respectively.

Ambient air quality in Bangkok will continue to deteriorate to an unacceptable level by the year 2000, if no action is taken over and above implementation of already approved projects (including mass transit projects). Carbon monoxide and hydrocarbon emissions could be reduced by 28 and 22 percent respectively, with the implementation of Reasonable Technology Measures used to control vehicle emissions alone. These measures include inspection and maintenance programs. Their success is dependent on effective quality control and on the application of stringent standards. However, these measures would have little impact in reducing the emissions of SPM. It can therefore be concluded that Reasonable Technology Measures will be insufficient to address Bangkok's air pollution problems, without complementary measures to reduce traffic congestion. Implementation of the traffic measures outlined under the Demand-ManagementPolicy Scenario alone will reduce CO and HC emissions by up to 45 percent. These measures serve to reduce traffic congestion and increase the average travel speed. However, in order to improve air quality to internationally acceptable levels, traffic measures must be implemented in conjunction with the Reasonable Technology Scenario. This will provide an additional reduction of CO and HC emissions by 45 percent.

The health impacts of air pollution in Bangkok are already causing concern. This study shows, that while proposed measures to alleviate traffic congestion and air pollution might improve the situation at the present day, they will do little to alleviate poor ambient air quality conditions in the year 2000. This is because of the projected increase in demand for transport in the future. It is therefore essential that both traffic and technology measures be implemented to address air pollution problems from traffic in Bangkok. Finally, two important observations need be further evaluated:

- In this study both traffic and technology measures are recommended in order to reduce air pollution to predetermined targets. We should not, however, neglect other measures, which could also be effective in reducing travel demand, and hence reducing the emission and concentration of traffic related air pollutants. Notably, other forms of demand-side management policy should be examined more closely, particularly measures concerning land-use planning and the provision of economic incentives to encourage the use of public as opposed to private transport.

- The costing aspects of these recommended measures have not yet been taken into consideration. This is, therefore, left for further study, at a later stage.

Appendix A: Traffic and Technology Scenarios

Table A.1 summarizes the three traffic scenarios:

Table A.1: Traffic Scenarios

Traffic Scenarios	Description of Scenarios
Do-Nothing Scenario	Using the 1994 network with no improvement and the trip matrix for the year 2000.
Do-As-Committed Scenario	Implementing planned measures for the year 2000 with the year 2000 road network (1994 traffic network plus committed and planned network)* and the year 2000 trip matrix.
Demand-Management-Policy	Including measures implemented under Do-As-Committed Scenario plus three major restraint measures: physical, quota, and pricing restraints with some bus transport improvement programs. Under this scenario, a number of projects are identified as follows: • Increase fuel price by about 25-30 percent. • Introduction of bus ways along major roads within outer and middle areas leading to inner sub-area. • Introduction of new traffic operation systems within inner areas such as extensive one-way systems, reversable lanes, parking controls and provision of suitable pedestrian facilities. • Introduction of new bus lanes in inner sub-area. • Introduction of feeder bus services in outer sub-areas,and some part of the middle sub-area so that the walking distance and waiting time for buses is between 5-10 minutes. • Introduction of bus terminals with park and ride systems and bus interchanges where commuters from nearby residential areas can walk. • Provision of more new air conditioned buses. • Provision of shuttle services within inner area. • Introduction of an area pricing scheme for the area within Ratchadapisak ring road.

* The network as planned by the government and committed to be constructed within this national plan or the next national plan

Technology scenarios:

Table A.2 summarizes the key assumptions regarding vehicle standards and proposed measures under the three technology scenarios.

Table A.2: Technology Scenarios

	Technology Scenarios		
	Base Case Tech.	**Reasonable Tech.**	**Best Tech.**
Assumptions regarding Vehicle Standards[13]			
Cars & Taxis	ECE R83 1994-1995 EEC91/441 1996+	ECE R83 1994-1995 EEC 91/441 1996+	ECE R83 1994-1995 EEC 91/441 1996-99 US 1996 in 2000+
LDGT	ECE 15-04 1994+	ECE 15-04 1994+ EEC 91/441 1996+	ECE 15-04 1994+ EEC 91/441 1996-99 US 1996 in 2000+
LDDV & LDDT	ECE R83 1995 EEC91/441 1996+	ECE R83 1995 EEC 91/441 1996+	ECE R83 1995 EEC 91/441 1996+
HDDT	EURO 1 1996 EEC 91/452 (A) EURO 2 2001 + EEC 91/542 (B)	EURO 1 1996 EEC91/542(A) EURO 2 2001+ EEC 91/542(B)	EURO 1 1996-97 EEC91/542(A) US 98 2000+
Motorcycles	ECE 40 1993-94 ECE 40.01 1995 Step 3 - 50% '95, 75%'96, 100%'97	ECE 40 1993-94 ECE 40.01 1995 Step 3 - 50%'95, 75%'96, 100%'97	ECE 40 1993-94 ECE 40.01 1995 Step 3 50%'95, 75%'96, 100%'97
Fuel Controls	No Evaporative Control for Hydrocarbon. Leaded gasoline use would be reduced to only 20 % by 1996. Sulfur levels in diesel fuel from the current 0.5% by weight to 0.25% by 1996.	Evaporative Controls on LDGV, Taxis & LDGT, Starting 1997. Leaded gasoline is assumed to be completely eliminated by 1996. No reductions are contemplated in diesel fuel's sulfur levels from the base case.	Evaporative Controls on LDGV, Taxis & LDGT, starting in 1997 US. Evaporative Test improvements will be employed. Leaded gasoline is assumed to be eliminated by 1996. Sulfur content in diesel fuel is reduced to 0.05% by weight by the year 2000. Conventional gasoline meets the US. Federal Gov't reformulated gasoline requirements by the year 2000[14].

[13] EEC and ECE refers to the European Community Type Performance Standards, which is applicable for new cars or other vehicles to be sold in that particular year. For motorcycles, the percentage given shows the government has set a target, for a certain percentage of vehicles sold in that year, and they *must* comply with that particular standard.

[14] These requirements don't specifically specify individual fuel parameters but rather require a 25 percent reduction in hydrocarbon and toxic emissions.

Appendix A

Appendix B

The MOBILE 5 Model

- Basic emission factors: In order to collect data for the emission models from a given vehicle type in actual use, EPA conducts the Emission Factor Program (EFP) in which randomly selected, privately owned vehicles (light-duty vehicles and light-duty trucks only) are borrowed for emission testing. All vehicles participating in the emission factor testing program have a Federal Test Pattern (FTP) test performed on them since the FTP is used to certify new vehicles with applicable emission standards, the real world performance of the fleet relative to this applicable emission standard is estimated. The emission factor program to date has included test results for more than 10,000 vehicles over more than 20 years of testing, covering model years from the current period to pre-controlled future conditions in Thailand, under a variety of conditions. This provides a substantial data base for the estimation of average in-use emission levels.

- Fuel characteristics: Emission test measurements are conducted on a standardized test fuel know as Indolene. The characteristics of this fuel are well defined and ensure that test results are repeatable. Since consumers cannot purchase Indolene at their local service stations and differences between the volatility of local fuels and Indolene can influence the level of both evaporative and tailpipe pollutants, the MOBILE 5 model requires the local input of fuel volatility.

- Tampering and misfueling: The basic emission factors in the MOBILE 5 model are adjusted to account for estimates of vehicle tampering rates as a function of accumulated mileage for each gasoline fueled vehicle category and eight categories of tampering (e.g. air pump disablement, misfueling, etc). These rates are combined with offsets (the increase in emissions that result from the given type of tampering) and added to the non-tampered emission factors. Options are available to input local tampering rates.

- Other correction factors: To ensure the repeatability of measurements, standardized test conditions have been specified for each vehicle category. They include driving cycle, temperature, humidity, vehicle load, and the distribution of starting conditions (such as cold or hot start) since real world vehicle trips do not match these test conditions very often, a series of correction factors have been developed to allow the emission factor model to account for differences.

  a) <u>Speed:</u> Emission factors are very sensitive to the average speed that is assumed. In general, emissions tend to increase as average speeds decrease from the 19.6 m.p.h. average FTP speed. The MOBILE 5 model does not assume an average speed, rather it requires that an estimate of the speed experienced by vehicles operating in the area and roadway segment, be specified. The MOBILE 5 model adjusts the emission factors for speeds other than 19.6 m.p.h. through the use of speed correction factors. These multiplicative adjustments to the base emission factors tend to follow a non-linear relationship that increase the emission levels as speeds decline from 19.6 m p.h., and increase beyond 48 m.p.h.

  b) <u>Temperature:</u> Emissions from mobile sources are significantly influenced by the ambient temperatures under which they are operating. Temperature has an effect on both the exhaust and the evaporative emission levels. The MOBILE 5 model deals with these effects separately. In general, exhaust emissions are at a minimum at the temperature specified for the FTP (75°F), with emissions increasing as temperatures either increase or decrease from that value. Nonambient temperature is assumed by the MOBILE 5 model. It can also be provided as input to the model. The MOBILE 5 model provides temperature correction factors for temperatures in the range of 0°F (i .e. -18°C) to 110°F (i.e. 43°C).

c) Operating modes: The MOBILE 5 model uses three inputs to indicate vehicle operating modes. These inputs represent Vehicle Miles Travelled (VMT); that is, the percentage of VMT (not the percentage of vehicles) accumulated by non-catalyst vehicles in cold-start mode (PCCN), and by catalyst-equipped vehicles in hot-start mode (PCCC). The three specified values must all be expressed as percentages (not as fractions). Each value must lie between 0.0 percent and 100 percent, and the sum of PCHC+PCCC must not exceed 100 percent.

d) Other correction factors: The MOBILE 5 model can provide four additional corrections to the exhaust emission factors for LDGVs, LDGTls and LDGT2s. These corrections are used to represent conditions not typically assumed in the MOBILE 5 model runs, and include the effect of air conditioning (A/C) usage, extra loading, and trailer towing on emissions. There is also a humidity correction factor, which applies only to exhaust NOx emissions.

- Control programs:-Emission factors are based on the performance of vehicles independent of any local control programs such as I/M, anti-tampering and Stage II refueling. Each of these programs is designed to reduce the level of pollutants emitted by vehicles operating under in-use conditions. Further, differences in program designs can have a significant impact on their effectiveness in reducing emissions.

a) Refueling emissions: The refueling of gasoline-fueled vehicles results in the displacement of fuel vapor from the vehicle fuel tank to the atmosphere. There are two basic approaches to the control of vehicle refueling emissions, generally referred to as "Stage II" (at the pump) and "onboard" (in the vehicle) vapor recovery systems. The MOBILE 5 model can model refueling emissions with no controls, as well as with either or both of the control options.

b) Inspection and maintenance programs: Many areas have implemented I/M programs as a means of further reducing MOBILE source air pollution. The MOBILE 5 model can model the impact of an operating I/M program on the calculated emission factors, based on the specification of certain parameters that describe the program.

c) Anti-tampering; programs (ATPs): Some areas have implemented these programs to reduce the frequency and related emission impact from emission control system tampering. The MOBILE 5 model allows for the estimation of the effects of such a program on the calculated emission factors.

- Vehicle categories: The Mobile 5 model computes separate emission estimates for eight vehicle categories:

1. Light duty gasoline-powered vehicles (LDGV), i.e. passenger cars;
2. Light duty diesel-powered vehicle (LDDV), i.e. diesel-powered passenger cars;
3. Light duty gasoline-powered trucks, type 1 (LDGT1), i.e., pickup trucks and vans that have a gross vehicle weight (GVW) of 0-6000 pounds;

4. Light duty gasoline-powered trucks, type 2(LDGT2), i.e., pickup trucks, vans and other small trucks that have a GVW of 6001-8500 pounds;
5. Light duty diesel-powered trucks, types I & 2 (LDDT);
6. Heavy duty gasoline trucks;
7. Heavy duty diesel trucks, and;
8. Motorcycles

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A Review of the Program Of the Office of the Commision for the Management of Road Traffic

By Kumropluk Saraswadi

Introduction

This report describes the development of a Mass Rapid Transit Systems Master Plan by the Office for the Commission of Road Traffic (OCMRT) for Bangkok as detailed in the full Master Plan document. The Master Plan documents addresses the following topic areas:

- Evolution of the Master Plan Concept
- Socio-economic and development benefits
- Transport model developm,ent and applications
- Ridership findings
- Environmental considerations
- Capital and operating costs
- Economic and financial analysis findings
- Priority projects and construction program phasing
- Implementation of the Master Plan - Insitutational Issues

Each of these topics is discussed in further detail in its own chapter in the document. For purposes of this workshop and subsequent proceedings, the last section will be hightlighted in the following excerpt.

Implementation of the Master Plan – Institutational Issues

To implement the Master Plan effectively, the creation of an appropriate institutation framework is an essential prerequisite. In particular, the development of a system which provides an integrated network of services to the public will require a high level of coordination, managementm and control.

The instituation framework within which the present set of mass transit projects is being developed is confused. There are a number of of high level bodies attempting to promote the development of mass transit services in Bagnkok and there has been a serious lack of coordination between these. In developing the proposals there has been no singly body attemptiong to ensure that the schemes are at least physically compatible where they intersct. Lately the Committee for the Mangementment of Roald Traffic (CMRT) and it supporting organziation, OCMRT, have attmepted to exercise a coordinating role, but their fundtion in this areas has been primarily advisory. Because of the way in which the initial concessions have been framed, CMRT and OCMRT do not have the authority to impose changes on the sponsorign organization or their concessionaires.

At a lower level there are a large number of organizations with repsonsibiltiy whcih have an impact on the effective implementation of transport schemes. The most importatn of these are defined below:

Ministry of Interior	Ministry of Transport and Communications	Office of the Prime Minister
• Police Department • PublicWorksDepartment • Town and Country Planning • Expresseway and Rapid Transit Authority • Bnagkok Metropolitan Administration	• Land Transportation Department • Highways Department • State Railway of Thailand • Bangkok Mass Transirt Authority	• Metropolitan Rapid Transit Authority

Because of this multiplicity of organziation cocnerned, there is a need to develop an instituational framework whcih can channel their efforts in a way which while protecting individual interests and providing a mass transit system, which meets the needs of the residents of Bangkok.

Development of Recommended Insitutational Framework

The key part of improving the institutional framework is to reduce the numbers of overlapping committees and authorities. At a policy making level the need is to include all the interested parties ina committee with clearly defined terms of reference which cover, as far as possible, all the issues associated with the provision and management of a mass transit system in Bangkok. Ideally, this should probably be under the responsibility of the Ministry of Transport and Communications, or possible the Ministry of Interior. However given the political structure in Thailand, it is recommended that this should be chaired by the Prime Minister.

The proposed membership of this committee provisionally names the Board of National Transportation Management Policy (BTRAN), would consist of:

- The Prime Minister, Chairman
- Deputy Prime Minister, Deputy Chairman
- Minister for the Prime Minister's Office
- Minister of Interior
- Minister of Transportation and Communications
- Minister of Finance
- Permanent Secretary of Interior
- Permanenet Secretary of Transport and Communications
- Permanent Secretary of Finance
- Secretary General, OCMRT
- Secreatry General, NESDB
- Director of Budget Bureau
- Governor of Bangkok Metropolitan Administration
- Secretary General of OBTRAN as Member of BTRAN

The Committee would be able to co-opt professional advisors or seek specific technical unputs as appropriate. The Committee would have the overall responsibility for setting policies to encrouage the development of a cost-effective and high quality public transport system in Bangkok, including mass transit services. A key element of this is the control of the approval and the financing of any proposals from public sector funds. No other organizations should have this aiblity, and, if necessary, the appropriate legal changes should be made. This Committee would therefore be the only forum for the discussion of issues assoicated with the provision and operation of mass transit services in Bangkok.

BTRAN would set the general policy guidelines for the development of mass transit services within Bangkok. The execution of these policies would fall to a separate office -- the Office of the Board of the National Transportation Managment Policy (OBTRAN).

Responsible Implementing Organization Options

Two basic models are availabe for execution of the mass transit projects. These can eitehr be undertaken by a range of orgnaniation as is proposed at present, or alterantively could be undertaken directly by an executive arm of OBTRAN. Given firstly the desire of the Government to invovle the private sector to a significant extenet, and secodnly the large number of public sector agencies with an interest in this area, the former approach, relying on separate bodies to implement schemes, to standards and specifications set by OBTRAN is probably the most appropriate. This would be able to make the best use of the present structure, allowing use to be made of the experience and expertise gained by potential project sponsors and concessionaires

APPENDIX A

TRANSPORTATION AND ENERGY EFFICIENCY: PROMISED POTENTIALS, SERIOUS ROADBLOCKS

By Terry V. Kraft-Oliver

Introduction

Transportation is both a critical element of achieving national economic development goals and a major consumer of scarce and expensive energy resources. Improvements in access and mobility from reduced congestion, higher speeds, additional non motorized and pedestrian options, and better mass transit will result in reductions in energy use in most cases. Additional improvements in vehicle efficiency are possible but will not meet the needs of the region for transportation and energy efficiency improvements in the absence of these other improvements.

Background

Transportation in Asia consumes about 25% of total energy use, costs about $90 billion[12] in direct costs and up to 20% of potential economic product indirectly through congestion penalties and health impacts, and is the second largest energy use sector in Asia. This is

[12] U.S. 1990 dollars. Energy Indicators. ADB. 1993.

the situation despite examples showing the way for a different future. Today Asia is rapidly turning its back on traditional transportation modes, in search of the modern. The current focus on transportation improvements are highways and very large transit projects. Asia must undoubtedly build additional modern transportation modes, yet the current means of doing so is locking Asian cities into the very kind of western isolating cultures so often held as examples to be avoided.

Asia contains over 3 billion people. Growth in urban populations and areas outstrips capacity to effectively serve these populations. Transportation and mobility of people, goods, and information is a critical activity for cities and governments in the region in order to continue the strong economic development gains of the last decade. Yet efficiency is paid scant attention and environment suffers from exceedingly severe levels of lead, particulate, carbon monoxide and other pollutants.

Historically transportation system development has meant massive investments in road infrastructure followed (and sometimes anticipated) by large and rapid increases in road vehicles, especially automobiles and trucks. This is often done at the expense of traditional and affordable transport modes especially non-motorized vehicles.

Promised Potentials

The technical potential to further improve energy efficiency in terms of fuel economy is large, a factor of three or more according to the OECD.[13] Such an improvement in Asia could significantly reduce expenditures for fuel and reduce emissions over the base case. An even more radical prediction of light vehicle technological change and the energy implications is noted in Lovins 1993. Lovins suggests that modern hybrid-electric drive cars could achieve 1.6 l/km with demonstrated technologies or twice that with advanced

[13] Cars and Climate Change. International Energy Agency. 1993. pp. 15.

technologies expected to be demonstrated in the near term. Yet both of these references, as well as others, indicate that simply making cars more energy efficient, even radically so, cannot produce the transportation gains needed to effectively meet existing demands for mobility let alone future demands. Nor can these gains offset the pollution impact of dependence on motor vehicle transportation. Neither can these gains support global and regional sustainability objectives.

In fact the improvements in mobility, reduced congestion, and improved energy efficiency and reduced environmental impacts comes from a more balanced approach which focuses on support for non-motorized transport, transportation system management, effective mass transit options coupled with limitations on vehicle use, and implementation of basic land use principles in a multi-faceted approach. Simply and directly, one must do many things together.[14]

The potential for improvement can be seen in the results from Curitiba Brazil. Despite an annual average population growth of 8 %, 70% of total weekday trips are on buses, per capita gasoline consumption is 30% less than eight comparable Brazilian cities. Environmental and economic indicators are improved as well. 400 new industries were added since 1973. Green spaces in the city increased from 0.5 square meters per person to 52 square meters per person. Former Mayor Jaime Lerner says that the roots of the improvements in Curitiba are in land use plans that were created and followed from 1965 onward.

[14] It is also true that one must be careful, as Jonas Rabinovitch formerly the City Planner for Curitiba Brazil and now with the United Nations Development Program notes, to "integrate the solutions rather than the problems." As anyone familiar with human nature will know, you can make a problem so big that no conceivable action can fix it. Transportation in Bangkok has reached these proportions, not because it cannot be solved, but because it is perceived as too big a problem.

Improvements can be seen in Asia in Singapore with doubling of average travel speeds, 10% bus fuel savings, and 30% reduction in air pollution in the morning peak. Singapore, already well known in this region for its far reaching and effective transportation solutions, began with an effective land use plan, originally described in the early 1960s and adapted over the ensuing years but not dropped.

Critical improvements in mobility, traffic congestion, commerce, energy and environment in these and other cities have come from integrating transportation and land use planning. Such integration leads to a conscious effort to minimize the number of trips needed. Land use - transport planning integration also seeks to minimize the length of trips in order to maximize the potential for short walking or cycling trips to work and shop.

Many cities in Asia are actively moving away from non-motorized transport because governments view non-motorized vehicles (bicycles, tricycles, pushcarts, etc.) as difficult to regulate, unsafe, inhumane and symbols of "backwardness."[15] Yet these options including walking, are the most energy efficient option, as well as preserving equitable availability of transport options for those who do not have access to motorized vehicles.

Equity is a large issue deserving more attention than it appears to get. In many cities in the world the poor walk, the rich drive. In Santiago Chile, 20 percent of all trips are by foot. The poorest sectors of the city spend 30% or more of their earnings on transport. They also spend a good portion of their life on traveling time.[16]

[15] Midgley, pp. 14.

[16] Henry Malbrán Rojas. Transport Solutions for People. E-notes, Quarterly Newsletter of the International Institute for Energy Conservation. Vol.4, No.1. January-March 1994.

In Japan, road statistics lag far behind Europe and North America, yet mobility does not. Pedestrian crossings increased from about 77,000 in 1967 to nearly 700,000 in 1985. In that same period total length of sidewalks increased from 5,600 kilometers to 73,000 kilometers. Pedestrian bridges increase from fewer than 800 to over 10,000 while pedestrian underpasses increased from about 100 to over 2,000. Bicycle paths showed similar large increases, from just over 10,000 kilometers in 1975 to 45,000 kilometers in 1985.[17]

It is not intended by these remarks, to recommend that roads, highways, and mega-projects not be pursued. It is quite apparent that in most cities road network improvements, transit projects, etc. must be pursued vigorously. However, pursuing these projects, while ignoring the opportunities for very short term improvements in mobility and access that come from increasing the friendliness to pedestrian and non-motorized transit, and the very long term benefits that come from integration of land use and transportation planning, is to work very hard to make things worse, not better.

[17] Midgley, pp. 21-22.

Table: Comparison of Emissions, Energy Use, Space Use, and Cost of Different Modes of Transport (per passenger-km).[18]

Mode of Transport	Persons per Hour per Lane	Energy Consumption per Seat-km (kWh)	Total Cost per Person-km (US cents)	Total Emissions per Passenger-km
Walking	1,800	0.04	NEGLIGIBLE	NONE
Bicycling	1,500	0.06	0.2	NONE
Motorcycle	1,100	NA	NA	27.497
Car	440-800	0.29	8.6	18.965
Bus:				
Mixed Traffic	10,000	0.12	1.4	1.02
Busway	19,000	0.09	0.9	0.89
Light Rail	18,000	NA	NA	Coal: 4.3520 Gas: 0.1876 Fuel Oil: 0.6261
Rapid Rail	54,000	0.15	2.4	Coal: 4.9651 Gas: 0.2307 Fuel Oil: 0.7102

[18] Moving Toward Integrated Transport Planning: Energy, Environment and Mobility in Four Asian Cities. Mia Birk and Christopher Zegras. International Institute for Energy Conservation. 1993. pp. 9.

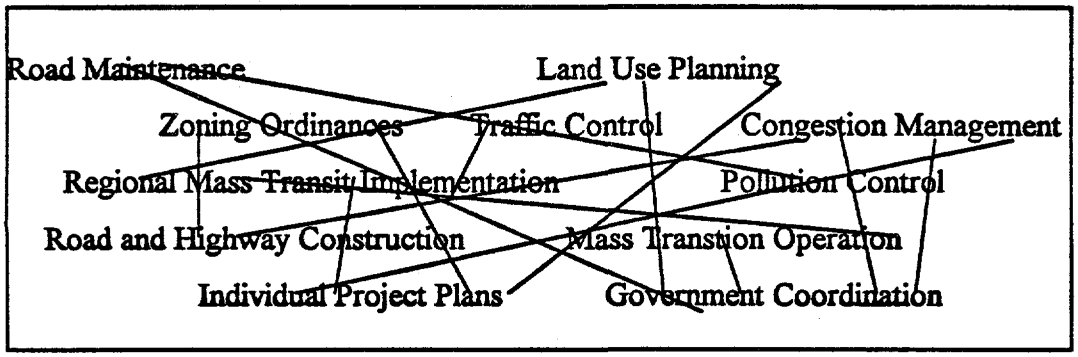
Serious Roadblocks

The barriers to success in the transport sector are obvious on a superficial level. They include lack of road space, inadequate or incomplete road networks, insufficient mass transit capacity, predation of pedestrian and NMV space by motor vehicles, and financing. The lack of progress in solving many of these problems over the past ten to twenty years indicates that there are underlying issues not yet addressed.

Perceptions of these problems have changed since the middle 1970s and early 1980s as international lending and technical assistance began to focus on transportation. In those early years the problems were described as financial, and "meeting demand" challenges.[19] The World Bank is now conducting a review of their Transport Sector Policy. While the review has not progressed to a final document and certainly not to articulation or transformation of Bank policy, early drafts reflect a view that past failures to improve transportation circumstances are human resource and institutional problems.

[19] World Bank Staff Working Paper No. 600 "Towards Better Urban Transport Planning: Developing Cities." J.M. Thomson. 1983

Figure 1. Complications in Transportation



In Asia the barriers to increases in mobility and accompanying improvements in energy efficiency are many. But they are not lack of information or advice. Nor are they lack of proposals for very large "mega-projects" touted to do everything to save cities from terminal grid-lock. The barriers are institutional, and relate to the ability of governments and bureaucracies to "do" effectively. These problems are rooted in Byzantine bureaucracies, split accountability, ineffective planning, and perceptions about development goals. In Bangkok responsibility for planning and implementation are effectively split many ways, resulting in more than 35 separate agencies and committees all having a hand in transportation issues. Such a large involvement could in some places indicate a will to action. In Bangkok it indicates that no one will be blamed for failure, and no advantage can be taken for success.

These kinds of institutional and governing failures will need to be addressed. Yet it is clear that change in these areas cannot be adequately addressed from outside. Indigenous organizations, including non-government organizations, will have to play a larger role to successfully address these kinds of changes. For both government and non-government organizations to successfully push for change, they will need information about the benefits, methods, and practices for effective "doing." Businesses, as one of the largest losers in dysfunctional transport systems, second only to the poor and clearly better resourced in both finances and skills, can play a large role in this movement.

Solutions in Search of Solvers

There are solutions. In some cases the solutions are so numerous they may appear overwhelming. Key to effective pursuit of theses possibilities will be finding "champions" to push them, and new approaches to building and broadening the capacity of various organizations to "do."

In at least one case the problems are so deeply ingrained, the promised solutions so tarnished and tattered with the retelling, that a renewed faith in the possibility for progress will have to be built. One approach to this rebuilding is finding and doing micro-incremental projects which can be accomplished over very short time frames, yet sum up to actual change in direction and impact.

Also in the short term, significant improvements can be made in mass transit design and operation. No current operating practice should be left unexamined. Curitiba and many other cities have made large improvements in mass transit effectiveness and attractiveness for very small investments. Bus ticketing, exclusive express lanes, feeder systems, and other changes to system operation have been shown to be successful innovations which increase ridership and reduce delays and travel time.

Other solutions are of necessity longer term. These include an improvement in the ability to quantify and compare alternative projects and policies on an even economic basis called Integrated Transport Planning. This concept, now under development by IIEC and experts from around the world fills between transportation planning practices currently in use, taking the practice to the next level of integration, and quantification, and will allow more robust comparisons of economic, political, and environmental impacts of policy and project choices related to transportation.

It is clear that the region's governments need to restore balance to use of non motorized and pedestrian options. These should be explicitly included within all sector technical and financial packages. In addition, these projects are very affordable for the governments of the region and could be the basis for micro-incremental projects noted above.

It is also clear that fundamental changes to decision processes need to be considered in some cases. This should be a target activity for multi-lateral and bilateral assistance to improve the capacity to analyze, compare, and select appropriate projects. This portion of the activity needed is a skills focused rather than democratic processes focused need. Additional assistance to and through NGOs will be needed to affect the use of democratic processes in transportation decisions.

Lastly, the second tier and third tier cities must not be overlooked. For every Bangkok or Beijing suffering incredible transportation disasters, there are Chaeng Mais and Anshans rapidly approaching similar problems.

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METRO MANILA TRANSPORT AND TRAFFIC MANAGEMENT PLAN (1993-1998)

By PRIMITIVO C. CAL

INTRODUCTION

In 1988, former President Corazon Aquino created the Presidential Task Force on Traffic Management to formulate plans and programs to improve the traffic situation in Metro Manila and to address the emerging problem of air pollution and concern on renewable energy sources for transportation. The Task Force formulated the Metro Manila Traffic Improvement Plan (TRIP) which was approved by President Aquino for implementation. TRIP called for the development of a mass urban transport system, which included the expansion of the light rail transit system and the construction and improvement of the Metro Manila road network.

Culled mainly from the TRIP proposals, the Updated Transport and Traffic Management Plan for Metro Manila (1993-1998) was developed through interagency discussions, public consultations, data collation and research work. The Plan was prepared by a technical working group composed of representatives from the Department of

Transportation and Communications (DOTC), Department of Public Works and Highways (DPWH), Metro Manila Authority (MMA), Presidential Management Staff (PMS) of the Office of the President, and: the Philippine National Police (PNP). Valuable inputs to the Plan were provided by the Philippine Motor Association and land transport industry groups. Full support was extended by the Metro Manila Mayors Council, which led to the approval by President Fidel Ramos of the Plan in 1993.

As provided under Presidential Executive Order No. 170, which approved the Updated Plan, the Metro Manila Land Transportation Coordinating Council (MMLTCC) was reconstituted and strengthened to improve coordination in plan implementation. The Metro Manila Authority has been designated as the lead agency in coordinating specific project implementation and resolving issues related to traffic management.

With the primacy of Metro Manila in all aspects of the Philippine economy, the efficient urban functioning of this metropolitan area has to be maintained. Beset by numerous urban problems in common with other developing cities of the world, the transportation and traffic situation of Metro Manila must be improved to ensure sustainable development. This paper presents the urban transport development strategies and programs for the Metro Manila of the future.

URBAN DEVELOPMENT AND TRANSPORTATION

SocioEconomic Profile

Metro Manila, which is comprised of the City of Manila, four other cities, and 12 municipalities, covers an area of 636 sq km within the center of the main island of Luzon. With an estimated population of 8.8 million in 1993, Metro Manila accounts for 13% of the total population of the Philippines. It produces almost a third of the national production output, with the share of the Gross Domestic Product steadily increasing from about 23% in 1948 to 31 % in 1993.

Despite the decentralization and regional dispersal initiatives of the government, Metro Manila still exerts a dominant influence on the economy and socio-political activities of the rest of the country. As the "National Capital Region," it is the seat of the national government and the premier center of business and trade. Metro Manila has most of the institutions of higher learning, the main health facilities, the banking establishments, and the major share of national cultural events. It remains the popular destination of tourists and has emerged as an international convention center.

The concentration of people, economic activities and employment opportunities in Metro Manila has brought about complex urban problems, notably of housing and of a progressively inefficient urban transport system.

Urban Transport Situation

The urban transport demand in Metro Manila is estimated at about 17.6 million person trips per day in 1990. This phenomenal growth from 11 million trips in 1980 is attributed to the strong linkages of the metropolis to the fast developing fringe areas and the sheer number of transient workers and students.

About 65% of the transport demand is served by public transport modes, with the ubiquitous jeepneys as the predominant mode. Bus and railway services, including the recently introduced light rail transit (LRT) system along two major traffic corridors, account for 34% and 3% of the public transport demand, respectively. The share of private vehicles has increased significantly from 26% in 1980 to 35% in 1990.

Another indicator of transport demand is the number and type of road vehicles in use. From 1980 to 1993, the number of motor vehicles registered in Metro Manila has grown at the rate of 3.1% per annum. However, since 1985, the total vehicle registration has been growing at an annual rate of almost 10%. Other aspects to consider are:

- **Public Transport**

The public transport services in Metro Manila is predominantly road-based, consisting largely of jeepneys and buses for primary and secondary routes, and tricycles and pedicabs for feeder routes. Since the highly urbanized areas extend to neighboring towns, short-distance provincial bus transport also forms an integral part of Metro Manila's public transport system. Public transport services within and linking Metro Manila use principally road vehicles. Intra-urban services are provided by jeepneys, buses (regular and air-conditioned units), mini-buses, rail systems, and tricycles. Inter-urban transport to/from neighboring areas are provided largely by provincial buses and jeepneys.

Jeepneys cover more than 610 km of Metro Manila roads, while buses operate only on about 350 km of the major corridors, with nearly 300 km being jointly serviced by jeepneys and buses. The existing route structure for jeepneys and buses provides modal complementation, except in certain major radial routes. Jeepney routes are generally short and concentrated in radial roads, while bus routes, typically passing through circumferential roads such as EDSA, are twice as long. Jeepneys are banned along most parts of EDSA, Roxas Boulevard and South Superhighway, which are designed to operate as high-speed road facilities.

Urban rail services, currently limited in coverage and patronage, are provided by the commuter trains of the Philippine National Railways and the LRT Line No. 1 along Rizal and Taft Avenues.

• Private Transport

Car ownership and usage have grown rapidly since the economic recession ending 1986. In Metro Manila alone, where about 43% of the national motor vehicie fleet and two-thirds of all cars are concentrated, per capita vehicle ownership is more than three times the national average. Private cars are increasing at the rate of 13% per annum.

Recent traffic counts indicate that private cars are the major cause of congestion in most Metro Manila roads, due mainly to their number and low occupancy, averaging at 2.2 passengers in 1990. Traffic congestion is expected to further worsen once the pent up demand for cars is not matched by major road capacity expansion.

• Road Network and Traffic Flows

The road system of Metro Manila consists of about 4,820 km of roads, including 1,827 km of private roads. The major arterial roads follow a semicircular and radial pattern, with only three completed circumferential roads, the most important of which is C-4 or EDSA, linking the 10 radial routes.

Many of the road sections have reached their capacity limits, particularly those within EDSA. It is estimated that nearly 40% of the arterial roads are heavily congested, specifically during peak periods. Due to vehicular congestion, the average traffic speed is recorded at 18 kph, with jeepneys and buses having lower overall speeds due to frequent service stops.

Transport and Traffic Problems

In general, the transport and traffic problems of Metro Manila are attributed to the deficiencies in public transport services and urban road network. The present state of the predominantly road-based public transport system is characterized by the low level of service in terms of travel speeds and passenger waiting times at stops, and the operation of dilapidated, Polution emmitting vehicles, despite the government-sponsored infusion of new buses in late 1989.

Moreover, the existing road system has become inadequate to meet the demands of the fast expanding metropolis. The road network is characterized by the partially developed arterial road system, inadequate distributor and collector roads, uncoordinated development and inaccessible private roads, and ill-maintained pavement and drainage structures. The transport situation is further exacerbated by the presence of too many cars and the operation of space-consuming jeepneys, with the latter now operating in traditionally bus routes. Moreover, traffic management, despite the introduction of computer-controlled signal systems, remained uncoordinated, particularly with the spotty and, oftentimes, inconsistent traffic law enforcement. The end-result is the severe traffic congestion experienced in most of the arterial roads, which further degrades the level of service of public transport modes particularly buses.

OBJECTIVES AND STRATEGIES OF THE PLAN

The medium-term Traffic and Transport Management Plan envisions to create an urban environment that would allow the efficient, safe, reliable, and affordable passenger and freight movements to/from and within Metro Manila. More specifically, the Plan is aimed at an overall reduction in travel time for commuters and vehicle drivers, integrated operation of transport services, and efficient interaction of traffic elements. Likewise, the Plan strives to minimize the adverse impacts of traffic flows on the physical environment, economic activities, and human activity systems.

The Plan shall be directed towards the development of a more responsive public transport system and an integrated network of public and private roads. In the short-term, specific action programs shall focus on more effective traffic management through the Three E's, namely: traffic enforcement, traffic engineering, and traffic education.

In line with the recently approved Philippine Development Plan (1993-1998), the following policies and strategies shall be adopted:

- Encourage increased private sector investments and participation in the provision, operation, and maintenance of urban transport infrastructure and services;
- Continuously upgrade facilities and service standards;
- Intensify efforts on traffic safety and environmental protection;
- Strengthen inter-agency coordination in policy formulation, planning and implementation of projects;
- Pursue further training licensing and other skills-upgrading systems for the transport industry and government authorities; and
- Promote low-cost transport system management measures in the short-term and strategic transport capacity expansion within the medium and long-term periods.

PLANS AND PROGRAMS

Transportation capacity in Metro Manila basically remained constant over the last decade. Additions to the road network were negligable. The same goes with the rail-based transport systems. So far, only the Line 1 of the Light Rail Transit has been built. The PNR commuter lines have even deteriorated.

Massive transportation infrastructure investments are needed in order for supply to match demand. Only then would the level of service go up to acceptable levels. It must be emphasized, however, that road building alone would not suffice. As experienced in big cities like Bangkok the problem of traffic congestion remains even after large investments had been made in road building. It seems that facilities create their own demand; they get filled soon after they are opened.

Road building must be complemented by the expansion of mass transit systems. This means more lines of the LRT should be built, as well as the rehabilitation of the commuter lines. Fielding of more buses could be stimulated through policy reforms and close coordination with the private sector, the main provider of public transport.

With the long lead time and huge resource requirements of transport infrastructure formation, the government will have to depend to a large extent on low-cost and quick-response transportation systems management (TSM) programs. Greater emphasis has been made on basic traffic engineering and management measures. Improved traffic law enforcement is found crucial to increase the effectiveness of traffic management schemes. Details of the Plan are given below.

Road Network Improvements

The Plan will pursue the construction of grade separation structures along major roads and the completion of missing road segments along the conceptual radial and circumferential road system of Metro Manila (Figure 1). The grade separation projects are mainly concentrated on EDSA, which is the principal arterial road of the metropolis. These projects cover:

- EDSA-Boni-Pioneer Underpass
- EDSA-Pasay-Ayala Underpass
- EDSA-Quezon Avenue Flyover
- EDSA-Shaw Flyover
- EDSA-Roosevelt Flyover
- EDSA-North Avenue-West Avenue Interchange
- C5-South Luzon Expressway Interchange
- Zapote-Alabang interchange
- Commonwealth-Tandang Sora Flyover

To relieve the current traffic load of EDSA, the construction/improvement of C5 from South Luzon Tollway to R 1 Expressway (Roxas Blvd . Extension) is proposed to be completed by 1998 at a total cost of close to US$ 1 billion. Moreover, the Plan includes the construction of the Manila-Cavite Expressway (US$100 million), introduction of about 59-kilometer, fully-elevated expressway system in Metro Manila using the road right-of-way of the existing radial and circumferential road network (US$ 950 million).

LRT Network Expansion

Under the Plan, the rail-based transport systems will provide trunkline services along with buses. Jeepneys will run on secondary routes, as well as serve feeders to the buses and LRT lines. The network of LRT lines is shown in Figure 2. It is proposed that LRT Lines 2 to 5 will be opened for operation not later than 1998. The capacity of the existing LRT Line 1 will also be increased by adding one car to the present two-car train. Line 1 is fully elevated and 15 km in length. It has the following technical features:

- Standard gauge track on elevated structures, seven meters above street level, supported by single columns
- 64 double-articulated light rail vehicles, which are coupled into two-car trains, with a capacity of 750 passenger/train and operating at an average commercial speed of 30 kilometers per hour
- 15 stations and three terminals located either at major road intersections or in commercial areas
- Eight traction substations for the conversion of the local power supply to the required 750 volts d.c.
- automatic light signals at each block section
- repair and maintenance facilities, including stabling yard at the Baclaran depot
- fare collection system using tokens for flat-fare operation

LRT Line 2, on the other hand, involves the construction of a fully-elevated line from Doroteo Jose Station of LRT Line 1 in Manila to Katipunan Avenue Quezon City, with a total length of 11.76 kilometers as well as the acquisition of 26 two-car trains with provision for future expansion (US$ 520 million). Future extension of this line will reach the municipality of Marikina.

LRT Line 3 or the EDSA Line involves the construction on a Build-Lease-Transfer (BLT) basis of a 17.8-kilometer, partly-elevated Light Rail Transit line from North Avenue, Quezon City to F.B. Harrison, Pasay City along Epifanio delos Santos Avenue (EDSA), including the supply of light rail vehicles, depot power plant and other electromechanical components (US$ 500 million).

Two other lines are currently being subjected to feasibility studies for BAT offering by early 1995. LRT Line 4 involves the design and construction on a Buiid-Operate-Transfer scheme of the 18.35 km., partly elevated doubletracked LRT line running from Welcome Rotunda up to Careen Highway in Novaliches via Commonwealth Avenue, with a total of two terminals and 18 intermediate stations (US$ 600 million). While LRT Line 5 involves the design and construction on a Build-Operate-Transfer scheme of the 7.55 km., fully elevated double track LRT line connecting the Shaw Blvd. Station of LRT Line 3 and A. Mendoza Station of LRT Line 2, running along Shaw Blvd., Magsaysay Avenue and A. Mendoza. This line will have a total of two terminals and five intermediate stations.

Traffic Management

Given the limited road space, the Metro manila authorities have to rely on the short-term on the application of traffic management measures. The objective is to make efficient use existing facilities. Measures that are being and/or will be adopted include: upgrading of the signal system, improvement in intersection layouts, public transport priority, travel demand modification and traffic restraint. Details of some of these measures are given below.

- Bus Only Lanes

Lanes dedicated exclusively to buses have been introduced along EDSA. Studies have yielded the following results:

- Bus travel times have decreased and number of round trips per bus increased; and
- Average travel speed of general traffic (non-users of exclusive lanes) decreased by 15 to 20%.

- Parking Control

Parking restrictions are being introduced to allocate the limited road space to moving vehicles. Where curbside parking can be permitted or desirable, particularly close to commercial establishments, parking fees are collected by attendants. Multi-storey parking garages are being built by private groups to augment on-street parking spaces. The most comprehensive parking policy and programs are in place in the main business district of Makati.

- One-Way Operation and Turning Prohibitions

One-way traffic regulation has been adopted in the roads surrounding the Ninoy Aquino International Airport and within the vicinity of the LRT Line 1. A comprehensive one-way system is found in Makati to allow more curbside parking and at the same time provide for the efficient flow of vehicles. Turning prohibition refers mainly to left turns along major thoroughfares such as Taft Avenue and Quezon Avenue.

- Truck Ban

A metropolitan-wide truck ban during peak periods (6:00 a.m. - 9:00 p.m. and 4:00 p.m. - 8:00 p.m.) has been in place since 1991. The ban aims to regulate the movement of trucks and vans on major roads, while designating alternative truck routes.

- Reversible Lanes

Reversible traffic lanes have been introduced along certain sections of EDSA and Commonwealth Avenue to increase road capacity in the peak direction of flow, particularly in the morning. This scheme has been noted to increase travel speeds along the sections where reversible lanes have been adopted.

- Segregated Bus Stops

Buses along EDSA are made to stop for loading/unloading operations on designated locations to minimize congestion at bus stops. Dwell times at this segregated bus stops have decreased due to the more orderly movement of buses.

- Towing of Illegally Parked and Stalled Vehicles

Mandatory towing of illegally parked and stalled vehicles along major roads has been adopted to clear obstructions to traffic movement. Penalties have been imposed on violators plus the cost of towing their vehicles.

- Other Schemes

The police are under strict orders to remove all road obstructions in order to effect the smooth flow of traffic. Alternative routes, including private subdivision roads, have been opened to light vehicles to ease the congestion on major roads.

IMPLEMENTATION PLAN

The main instruments to implement the Plan include the following:

- Investments, including government investments and public-private sector partnerships; and
- Policy and Regulatory Measures, including institutional linkages, regulations in terms of standards, licenses, permits, and operating rules and practices, and market-based incentives relative to taxes, subsidies, and user charges.

For effective and coordinated implementation of the Plan components, the existing Metro Manila Land Transportation Coordinating council which is composed of all transport and traffic-related agencies and civic organizations, is to be strengthened. Moreover, a Plan Monitoring and Evaluation System will be established to support the Council. Full cooperation with local officials will be ensured through the direct linkages with the Metro Manila Mayors' Council.

Investments

It is estimated that the Plan will require about US$ 6.6 billion, of which around US$ 3.5 billion are expected to be provided by the private sector through the BAT scheme of project implementation. The detailed breakdown of costs are indicated below.

- Mass Transit - US$ 2.8 billion
- Road Infrastructure - 3.8 billion
- Traffic Enforcement - 4.1 million
- Traffic Education - 1.0 million

Policy and Regulatory Measures

As the private sector directly provides the land transport services, the role of government will simply be to establish an environment conducive to private sector participation. To promote greater involvement of the private sector in the provision of infrastructure and services, the government has adopted the principle of deregulation, which generally means the removal of bureaucratic red tape and liberalization in the production and trade in goods and services and flow of investments. This translates in the transportation sector into the easing up of restrictions in entry into the transport service industry, cost-based setting of tariff, and flexibility in the allocation of transport units in the various routes. Deregulation of transport services is expected to lead to more competition and increased benefits to passengers and shippers of goods in terms of lower fares and charges, and higher levels of service. However, this liberalization regime is coupled with stricter enforcement of safety regulations.

Where government assistance will be required by the private sector, various forms of incentives will be provided. These may include tax and import duty-free importation of capital goods, income tax holidays, net operating loss carryover and accelerated depreciation of assets. In some instances, the government will grant direct subsidies as in the cost-sharing of major infrastructure projects or the use of concessional loans extended to the government. Under the recently amended BAT Law, proponents from the private sector may avail of performance guarantees from the government, including other types of performance undertakings and incentives.

Education Program

As identified under the Plan, there is an immediate need to launch fresh initiatives to raise road discipline and safety awareness levels in the public. This has been undertaken through an Information and Education Program which will be undertaken in Metro Manila. The program aims to:

- Promote awareness of the importance of road safety consciousness in creating a safe and orderly road and road transport operation;
- Coordinate all public information and education programs as well as existing resources for maximum impact and wider coverage; and
- Forge better and closer working relations and pursue cooperative undertakings with the participation of the private sector.

The program has adopted an intensive tri-media campaign to harness the medium of communication to the optimum and to better reach the target groups. Print, radio and television media has been tapped for this purpose. The program includes the following components:

- A learning module series on road safety for the pre-school, elementary and high school levels
- Publication of manuals and pamphlets on traffic rules and regulations, and safety topics, possibly in comics form such as the Land Transportation Office (LTO)
- Preparation and airing over the radio and television of road safety documentaries
- Publication of regular newsletter on road safety
- Conduct of trainers-training program and subsequent local training programs for traffic law enforcers and accident investigators
- Establishment of a pilot, mini-traffic safety park in Metro Manila
- Production of radio and television plugs, and slogan-stickers for motor vehicles

Enforcement Program

The Traffic Enforcement Program shall enhance and increase the visibility and mobility of the traffic enforcers. This involves the- hiring of more personnel, acquisition of support equipment and vehicles review/updating of traffic rules and regulations, strengthening of prosecution systems through the traffic courts, and training of traffic enforcers, including auxiliary units. The policy on localization of traffic law enforcement into the five police districts of Metro Manila will be continued for effective administration.

The Plan envisioned the strict enforcement of traffic laws, rules and regulations, and the strengthening of capability of traffic law enforcers, particularly in terms of staff training and logistical support. The main components of the Enforcement Program include:

- Review and updating of traffic laws, rules and regulations
- Establishment of performance-oriented monitoring and evaluation system for traffic law enforcement

- Adoption of single ticketing system and its computerization
- Revalidation of all driver licenses and vehicle registration records
- Procurement of vehicles and other equipment, particularly communication facilities to upgrade the capability of the traffic enforcers
- Retraining and advance courses for traffic policemen and aides

CONCLUSION

The improvement of transport efficiency in the country's premier urban center hinges on the formulation and subsequent promotion of an overall strategy, which comprises policy measures, institutional development and investment components, consistent with the government's development objectives. Urban transport policies should ensure better utilization of available resources, promote cost-effectiveness in the delivery of services and increase the productivity and efficiency of transport organizations. Effective institutional coordination and strong institutions are crucial components of this strategy and often influence the long-term success in the sector. Transport investments should corresponds to established priorities.

The Updated Transport and Traffic Management Plan (1993-1998) as presented in this paper outlines this fresh initiative to pursue an overall urban transport strategy for the continued growth of Metro Manila. This Plan is directed towards the development of a more responsive public transport system, expansion of road network capacity, and improvement of traffic management and enforcement. Constraints may be present along the way but opportunities and potentials exist for the deliverance of daily commuters straggling to make a living.

Demand Management Implementation in Southeast Asia

By Yordphol Tanaboriboon

Introduction

The need to apply transportation system management, to developing countries is urgent. Attempts to alleviate severe traffic congestion in their metropolises have so far failed to provide adequate solutions. The countries are faced with many difficulties because of the lack of sufficient financial resources together with their complex internal administrative and political problems. They are incapable of providing sufficient road space to cope with the escalating demand in private automobiles. This has led to excessive delays in urban traveling, environmental pollution problems, decline of road-based public transit services and deterioration of the quality of life in these metropolises.

Demand management, in use for decades in the Western world, has also been recognized in Singapore's famous area licensing scheme (ALS) making other Southeast Asian Metropolises aware of its advantages as an alternative in solving their chaotic traffic problems. However, realization is far different from implementation and still many metropolises are not able to apply the technique. Singapore and Thailand, two leaders among many other Southeast Asian regions in economics, tourism, trades and industries, handle their problems far differently, especially the traffic congestion problem. While a number of demand management schemes have been implemented successfully in Singapore since 1975, Bangkok is still struggling to implement such measures to alleviate severe traffic congestion problems. This article intends to high light the successful practices and unsuccessful attempts of demand management techniques applied in Singapore and Bangkok.

Demand Management in Singapore

In the Southeast Asian metropolises, Singapore can be described as the most successful metropolis in solving urban congestion problems by means of various demand management strategies. As a city state, Singapore has limited land resources with an area of about 630 square kilometers and a population of three million. The rapid rise in the standard of living over the past decades together with the urban-based transportation system, resulted in road congestion problems and rapid growth of private car ownerships.[1] In order to tackle these problems, Singapore has implemented various demand management measures during the past 16 years. These include the ALS and a number of private car ownership restraints policies through various tax schemes and other demand management measures. All these techniques will be highlighted in the following sections.

The concept of demand management might not be complete without mentioning the details of Singapore's unique ALS. In 1973 recommendations from the Road Transport Action Committee (RTAC), comprised of various permanent secretaries from the ministries of National Development, Communications, Finance and Home Affairs, together with other auto restraint policies created the beginning of the ALS.[2] On June 2, 1975, the Singapore government implemented the scheme to restrain the use of private vehicles in the central business district area. Under the ALS, a charge was applied to low-occupancy vehicles entering the restricted central business district area during the morning peak period. Private automobiles with four or more occupants, goods vehicles, buses and motorcycles were exempted from paying the charge. However, these privileges have since been removed. All vehicles, including any private cars irrespective of number of occupants are required to pay ALS fees, currently priced at S$3 (US$1 = S$1.8) for all vehicles and S$1 for motorcycles. However, buses still are exempted from this regulation. Drivers are required to display a license on their windshield when driving into the restricted area during the specified periods, 7:30 a.m. to 10:15 a.m. and 4:30 p.m. to 7 p.m. Permits or licenses can be purchased at authorized kiosks on major roads approaching the restricted zone. Motorists who fail to have a license are subject to violation, and the fine is S$50. Currently, not only the restricted hours have been extended but the restricted area also has been expanded from 500 hectares (ha) to about 650 ha.

Initially, it was feared that the ALS might adversely affect business and other activities. However, the effects have not been substantiated. Any impact that it might have had on the land use, land values and environment, has been largely eclipsed by other factors in the economy.[3] Despite the effect of ALS, which contributed to the drastic 73 percent decrease of private cars entering the restricted zone as reported by the World Bank,[4] the country prospered and its car population continued to increase by 9.8 percent and the total number of vehicles by 6.4 percent in the year ended April 30, 1989.[5] Because of the continued increase, the government introduced new strategies to restrain auto demand that are perhaps more controversial and much tougher strategies.

Effective May 1, 1990, the Singapore government decided to introduce the unique and perhaps astonishing "quota" system, which allows only a limited number of new vehicles to be registered each year.[6] Before the purchase of any new cars, drivers must obtain a Certificate of Entitlement (COE) through bidding in a monthly public tender exercise. The number of successful bids are equal to the limited quota fixed for that particular month and for a given type of vehicle. This quota system covers all categories of vehicles including trucks, buses, and motorcycles. To obtain a COE, each successful bidder has to pay a quota premium equal to the lowest accepted bid for each particular type of vehicle. However, those successful bidders in the "open" category can use the COE to purchase any types of vehicles as desired.

Quotas (or maximum number of vehicles that can be registered) are determined by the Ministry of Communication. Currently, the quotas for each type of vehicles follow recent trends in registration of new vehicles, for example, the total number of new private cars registered in 1989 was 33,155 and for the year 1990 (May 1, 1990 to April 30, 1991) the quota was set at only 29,195 vehicles, a 12 percent reduction compared to 1989 total new cars registered. Table 1 shows the quotas for each type of vehicles during the 1990-91 periods, classified in four different quota periods. To bid for the COE, a prospective car buyer must deposit half of the bid upon application, and only one bid is permitted a person. However, authorized car dealers can place up to a maximum of 100 bids. Each entitlement is valid for 10 years, and the COE also is transferable. Although COE is not required in purchasing used vehicles, owners of vehicles in excess of 10 years must pay the "prevailing quota premium" if they desire to continue using their vehicles. Nonetheless, once acquired, they can use their vehicles for another 10 years.

Besides the unique quota system currently implemented to curb car ownership, Singapore also introduced other measures in reducing peak demands. One measure encouraged motorists to use the "special license" scheme, which permits vehicles to be utilized only during the noncongested periods of nighttime, weekends and holidays. Under this plan, the government offered incentives of cheaper car prices, S$15,000 reduction upon registration of the new car, together with a 70 percent reduction in annual road tax.[7]

This measure, known as "weekend car" scheme, took effect on May 1, 1991. It allows motorists to use their cars only from 7 p.m. to 7 a.m. on weekdays, after 3 p.m. on Saturdays, and all day Sundays and holidays. Utilizing these special weekend cars at other than specified time periods is possible by displaying a special daily coupon. Five free coupons are given every year and additional coupons can be bought at S$20 each. Motorists who opt for this scheme are given a special registration plate fixed with special seals that break when the plate is removed. The penalty for using a weekend car with a normal car's license plate is twice the amount of normal annual road tax. An owner who uses a weekend car during regular hours without displaying a special daily coupon is fined with a minimum of half the normal annual road tax.[8]

Apart from these two extraordinary demand management techniques, other usage restraints such as increment in annual road tax and prohibitive registration fees also are worth taking a close look at. Over the years, the government has implemented various fiscal measures to discourage auto ownership and usage. Since 1972, the government has increased the annual road tax by 10 times. For a typical U.S. car of 2,000 cc to 3,000 cc, the annual road tax increased from 10 per cc in 1972 to the current tax of $1.25 per cc. Details of the progressive increment in annual road tax are presented in Table 2.

Moreover, to obtain a new car in Singapore, aside from paying the usual import duty, registration and license plate fees normally practiced in many countries, Singapore motorists also are required to pay the Additional Registration Fee, known as ARF. ARF was first introduced in 1972 and was calculated at 25 percent of the open market value (OMV). OMV consists of manufacturers prices, insurance and freight costs. As is common with other measures, ARF has also been increased several times: to 55 percent in 1974; 100 percent in 1975; 125 percent in 1978; 150 percent in 1980; and 175 percent in 1983. However, with the on-going quota system, the government decided to reduce the

ARF to 160 percent to offset the cost of the COE, which took effect on November 1, 1990.

It also is interesting to mention that though the registration fees have increased only twice since 1972, each increment was substantial, especially when compared to the previous registration fee. Singapore motorists were hard hit by the increment in the registration fee from S$15 to S$1,000 on February 6, 1980. Ten years later, in February 1990, the registration fee rose again to S$6,000. This increment was only temporary, however, as an interim measure employed to discourage a rush in purchasing vehicles before the quota system took effect. Right after the implementation of the quota system, the registration was rolled back to its original fee.

Aside from these traffic restraint techniques, other demand management measures implemented in Singapore include transit improvement, parking control, ride sharing, peak-period dispersion and land use control measures. Improvement of the bus services through acquisition of new and modern buses, revision of more efficient bus networks and implementation of bus priority through the provision of bus lanes have all been implemented. Moreover, the rail mass transit system was augmented on March 1, 1988. This mass rapid transit system expects to carry 800,000 passengers daily when their entire networks of 67 km are fully completed.[9] On the other hand, a 30 percent to 100 percent increase in parking fees[10] also is being exercised to enforce the parking control policy. Other demand management measures include the land use development strategy, which attempted to minimize the need for travel through the provision of new generation self-contained satellite towns and a campaign to promote staggered working hours.

The successful implementation of demand management strategies in Singapore cannot be denied. Besides the effective measures being implemented, the Singapore government also is closely monitoring and constantly maintaining transport demands to a manageable level. Motorists shoulder the burden through taxes and tariffs whenever the need arises to control increasing traffic congestion. Despite the fast growth of the per capita incomes of Singapore's inhabitants, which is over twice the average of Western European countries and nearly four times the long-term average growth rate of the United Kingdom,[11] the government still managed to maintain the level of congestion through various effective demand management strategies.

Implementing the electronic road pricing scheme in 1996 is another challenge fast-approaching Singapore.[8] Hong Kong's government decided to delay the introduction of electronic road pricing scheme indefinitely because of strong opposition from the public.[12] Although there are several years before implementation, Singapore might again prove to be the sole Asian metropolis to implement this advanced road demand management technique.

Demand Management in Bangkok

If demand management is considered as two sides of a coin, one side represents Singapore's successful implementation and the other side represents Bangkok's unsuccessful attempts. There are few demand management measures practiced in Bangkok, despite its severe traffic congestion problems that have an adverse effect on commuters and quality of life. Bangkok's congestion problems became widely known when Newsweek published an article on traffic problems in Bangkok.[13] One of the many problems cited included, "One traffic researcher recently estimated that if all transportation projects will be implemented within the next 15 years - an undertaking that would cost roughly $15 billion - they would speed up the flow of traffic by only one kilometer per hour. New cars keep hitting the city's streets faster than roads can be built."

Unfortunately, even with the increasing traffic congestion, demands have been allowed to grow virtually uncontrolled. In 1960, there were fewer than 100,000 vehicles registered in Bangkok, 10 years later, in 1970 the number increased to about 300,000 vehicles. Fast growth rate in vehicles has continued in Bangkok. In 1980, there were 600,000 vehicles running in the metropolis. The unsuccessful attempts and inability to curb the purchase of automobiles have raised the number of registered vehicles to far beyond expectations to the 2.3 million in 1990. Details of vehicle statistics for the past 10 years are shown in Table 3. The need to implement demand management measures in Bangkok is now indisputable.

Though, several attempts have been initiated to implement demand management strategies in Bangkok, successful implementations have not yet been realized. In 1975, the first comprehensive transportation study, "The Greater Bangkok Area Transportation Study,"[14] was carried out by a German study team together with a Thailand counterpart. Some of the recommendations related to demand management include:

- A policy of restraint on private car ownership and use

- A bus operated mass transit system should be constructed, capable of conversion to rail at a later date
- In the medium term (1980) 65 kms of expressway and 50 kms of mass transit should be constructed.

None of these recommendations has been implemented except the completion of the first stage of an expressway 27.1 km in length. Although a design study team had been commissioned for the mass transit system, final implementation is still far from realization.

The elevated light rail transit "Skytrain" project, which finally has been selected as the Bangkok rapid transit system, is a controversial project because of political pressures as well as the unsettled certain financial agreements. Despite the awareness of the need for the system by both authority and residents, the project is still not under way.

However, the significant role of demand management has not been totally ignored. In early 1978, with support from the World Bank, the Bangkok Traffic Management Project (BTMP) was inaugurated. Certain measures related to demand management were recommended, which included[15]: a) improving public transport, bus priority measures, including bus lanes and bus bays, and b) policy measured to discourage low-occupancy vehicle use, including introduction of a road pricing schedule; parking controls to discourage commuter parking; and staggered work and school hours.

A part from the various land transit modes, Bangkok commuters can take advantage of the geographical location of the Chao Phraya River and its tributaries by using water transport modes.[16] However, the authorities have not done much to improve the services, which thus far have been provided solely by private operators. As such, bus transit has become one of the major modes of transport and will probably continue to be for the next decade or so, even with the existence of the Skytrain project or perhaps other rail mass transit systems. The bus system will still be required and demanded by commuters, even though it does not provide adequate service to the public.

One possible solution to improve bus service is to provide bus priority through the implementation of bus lanes. As recommended by the World Bank, on May 1,1980, the extensive network of about 100 kms with-flow bus lanes were implemented on 17 major arterials throughout Bangkok, and on Sept. 15, 1980, four more routes were added to the network. These with-flow bus lanes, together with the previous contraflow bus lanes of 11 routes, give Bangkok one of the most extensive system of bus lanes in Southeast

Asia.[17] Although positive impacts of bus lanes were initially reported in Bangkok, bus lanes became less effective as other vehicles illegally intruded on the bus lanes. Because of insufficient road space to cope with ever-increasing vehicles and improper enforcement, today bus lanes are almost ordinary lanes except for some contraflow bus lanes still functioning effectively. Special privileges for bus-only lanes are slowly fading, another unsuccessful attempt to apply the demand management concept in Bangkok.

Aside from the unsuccessful improvements in bus transit, other aspects of demand management also were considered by the authorities. Implementing a traffic restraint strategy through road pricing scheme was seriously considered and had been agreed to "in principle" by the Thai government,[15] and in 1979 the recommended cordon pricing scheme was proposed to the government. This scheme was similar in principle to that in operation in Singapore - specific vehicle types must obtain licenses to cross into defined restraint areas during restricted periods. However, the cordon pricing scheme has never been applied. Fear of strong opposition and unpopularity the government might have faced, together with the uncertainty of political impact, the project has been abandoned indefinitely.

In 1985, another proposed traffic restraint measure was through the study on "Metropolitan Bangkok Short Term Urban Transport Review."[18] In this Study, the proposed measure, called Traffic Improvement Program (TRIP), aims not only to reduce traffic in the congested inner area of the city but to set up a self-financing program by charging toll fees. Once again, similar hindrances prolonged decision making, and implementation of this restraint strategy might not be possible unless drastic changes take place.

Other than the unsuccessful attempts to implement the traffic constraint strategy through road pricing schemes, the government has been using other measures, such as parking control, staggered working hours and ride-sharing campaigns through provision of school buses and staff buses. On April 15, 1990, the Bangkok Metro Police Bureau announced the prohibition of on-street parking along 314 streets throughout Bangkok. Some were imposed during the peak periods only, while some were implemented all day long. However, similar to many other measures, full-scale implementation has been delayed several times and motorists were violating restrictions. The lack of sufficient police to strictly enforce the restrictions contributed to the failure in implementing this parking control scheme. Nonetheless, the police are now considering an idea for more effective enforcement through the use of the wheelclamps available still are a challenge.

Attempts to alleviate traffic congestion in Bangkok are still progressing, though not efficiently. The current National Traffic Committee under Gen. Pow Sarasin, the deputy prime minister, is implementing staggered working hours in public offices for a trial period of three months. The choice of three working periods, 7:30 a.m. to 3:30 p.m., 8:30 a.m. to 4:30 p.m. and 9:30 a.m. to 5:30 p.m., are provided for public servants instead of the previous typical working hours of 8:30 a.m. to 4:30 p.m. Despite some criticism that the scheme might not be practical because many parents send their children to school, it was implemented and will remain permanent if found effective. In initial reports quoted from one of the local newspapers, Pow stated, "I believe there were some improvements in the city's traffic conditions.... About 20 percent of the workers selected 7:30, 60 percent chose 8:30 and the remaining 20 percent preferred 9:30 a.m. to start working." (Thai Rath , Oct. 4, 1991)

School trips syndrome might not sound familiar to many, but is quite well known in Bangkok. Many Tahi parents send their children to and from schools using their own private cars. According to one of Japan International Cooperation Agency's studies, the number of school trips during peak hours represented almost one-third of the total trips made in Bangkok in 1989.[19] Thus, ride-sharing strategy should include measures to reduce this phenomenon and perhaps the most appropriate action is to encourage using school buses. The ongoing traffic committee currently is examining the possibilities of implementing a school bus system with high hopes that this scheme will become successful.

It would be unfair not to mention one of Bankok's successful schemes. For a number of years, Bangkok has been restricting trucks from operation in the city during peak periods. Restricted times for 10-wheeled trucks are 6 to 10 a.m. and 3 to 9 p.m., and 4 to 9 p.m., except holidays. These restrictions significantly reduce urban travel costs and congestion.[20] It is interesting to note that restrictions of truck operations during peak periods are well accepted by motorists. However, restrictions of truck operations during peak periods are well accepted by motorists. However, restrictions on private car ownership and usage might not be acceptable and could easily become an endless heated debate, leading to one typical conclusive remark, that traffic restraint technique is not practical and suitable for Bangkok.

Contrary to Singapore's successful implementation on fiscal measures, annual road taxes in Thailand for any types of vehicles have remained unchanged for the past 10 years. In fact, road taxes on private cars are extremely low, especially when compared to the price of the cars. For instance, the price of a new Mercedes Benz 230E (2,299 cc) is about 2.6 million Baht (US$100,000) but the annual road tax is only 4,096 Baht (US$158), equivalent to .15 percent of the car price.[21] The government is now attempting to revise the annual road tax rates hoping to apply this new revision in the near future. However, like other measures, the cabinet has not yet rendered their final approval on this scheme.

On Oct. 3, 1991, local newspapers reported the results of the meeting of the Economic Screening Committee, quoting spokesperson Dr. Pisit Pakkasem, secretary-general of the National Economic and Social Development Board: "Presently, the growth rate of vehicles is about 12 percent to 13 percent per annum and expected to grow with this rate for the next tow to three years. While the area for roads may increase less than 1 percent of the total area." (*Bangkok Post and Ban-Muang,* Oct. 3, 1991). If the prediction on the vehicle growth rate of 12 percent to 13 percent per annum holds true and the current number of vehicles, what more can be expected in Bangkok in the next few years to come?

Conclusion

The successful implementation of various demand management schemes in Singapore cannot be denied and will remain for sometime to come. Perhaps, no other metropolis in Southeast Asia or even in the world can equal implementing its unique techniques of area licensing scheme, quota system or weekend car project. Considerable measures of success of demand management schemes can be highly attributed to Singapore government's recognition of the benefits and the will to overcome the difficulties of introducing such unpopular schemes. Another reason is the strong and efficient enforcement: they provide preventive measures for possible forgery and further imposed the drastic high penalty.

On the contrary, the Thai government is much more hesitant to implement such unpopular measures despite many studies being conducted. The government is reluctant to implement even on a trial basis fearing that it might face strong opposition from the local commuters and opposing political parties. Common excuses being cited are the intrusion of people's freedom and disturbance of democratic atmosphere. Nonetheless, before the successful implementation of any demand management schemes, the government must provide proper alternatives especially the efficient and effective mass transit systems to cater to the need of the populace. This article firmly believes that despite the prolonged decision in implementing any demand management measure, but with the ongoing severe traffic congestion problems in Bangkok, eventually, the Thai government has to impose some if not all demand management techniques.

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Transport Policy-Making and Planning for Javanese Cities

By Harry Dimitriou

Based on findings of field studies in five Javanese cities in Indonesia, this paper looks at a hierarchy of settlements and investigates what aspects of urban development and the transport sector most influences transport policy-making and planning in the country. The paper highlights the presence of a community hierarchy within these settlements with consonant trip-making patterns and the widespread mis-use of certain transport modes. The paper cross-relates observed transport problems and policy issues diagnosed from the five Javanese cities with an earlier prepared national agenda of urban transport policy issues and problems. This is done with a view to arriving at more sensitive policy and planning responses nation-wide for cities of different kinds in Indonesia.

The paper commences with an explanation of the settlement hierarchy and community structure employed by Indonesian government planners An attempts is then made to relate this hierarchy and structure to the five cities studies. Within this context, factors affecting urban transport are discussed and tabulated against the above cities settlement hierarchy. these include aspects of: settlement size, structure and area; settlement development policy, urban for, density and topography; and travel and transport characteristics.

An attempt is made to match this settlement hierarchy (and its constituent community structure) with a conceptualized hierarchy of transport modes, simultaneously investigating: the relationship between urban communities and assigned road hierarchies; community-based travel demand and trip-making characteristics; and the relationship between travel, speed and distance. From this an assessment is made of the performance and current use and mis-use of such transport modes.

Finally, a topology of settlements and related transport problems are drawn-up, highlighting those problems that are specific to particulart types of settlements, and between transport infrastructure, service and planning problems. The paper concludes by arguing the case for both city-wide and community-wide continuous transport networks' for pedestrians and compact slower-moving transport modes to accommodate the greater part of short distance urban travel. Excerpts of relevant chapters are included in the accompanying Appendix A.

APPENDIX A

4 Transport Policy-Making and Planning for Javanese Cities

The following account, together with Appendices 1 and 2, provide a summary of the findings of field studies directed by the author in five Javanese cities in 1987 in Bandung, Solo, Magelang, Salatiga, and Banjarnegara (referred to hereafter as the 'sample cities' (see Figure 4.1) (1). Subsequent visits were made in 1992 to up-date the information collected where possible. The sample cities are representative of a settlement hierarchy currently employed by the Government of Indonesia for national urban policy-making (see Table 4.1). They were studied with a view to confirming the following at the local level:

- those aspects identified in the preceding chapter and Appendix 2 as having an influence on transport in Indonesian cities;
- the presence of a settlement/community hierarchy and consonant trip-making patterns of the kind identified by Sasaki (1970);
- the mis-use of transport modes in urban areas in the way identified by Bouladon (1967a and 1967b);
- urban transport related problems and policy issues identified at the national level.

Settlement Hierarchy

The type of cities visited in support of the research cited here range from a metropolitan area of 1.8 million inhabitants (Kotamadya Bandung) to a market town of some 66,500 inhabitants (Banjarnegara) (see Table 4.2).

Table 4.1: Hierarchy of Indonesian Settlements by Population

Settlement Typology	Population Range		
Conurbation	5,000,000	and above	
Metropolitan Cities	1,000,000	to	5,000,000
Large Cities	500,000	to	1,000,000
Medium Size Cities	100,000	to	500,000
Small Cities (A)	50,000	to	100,000
Small Cities (B)	25,000	to	50,000
Large Rural Towns	10,000	to	25,000
Medium Rural Towns (A)	5,000	to	10,000
Medium Rural Towns (B)	3,000	to	5,000

Source: Chapter 2, UNDP / UNCHS, 1985, vol. 1

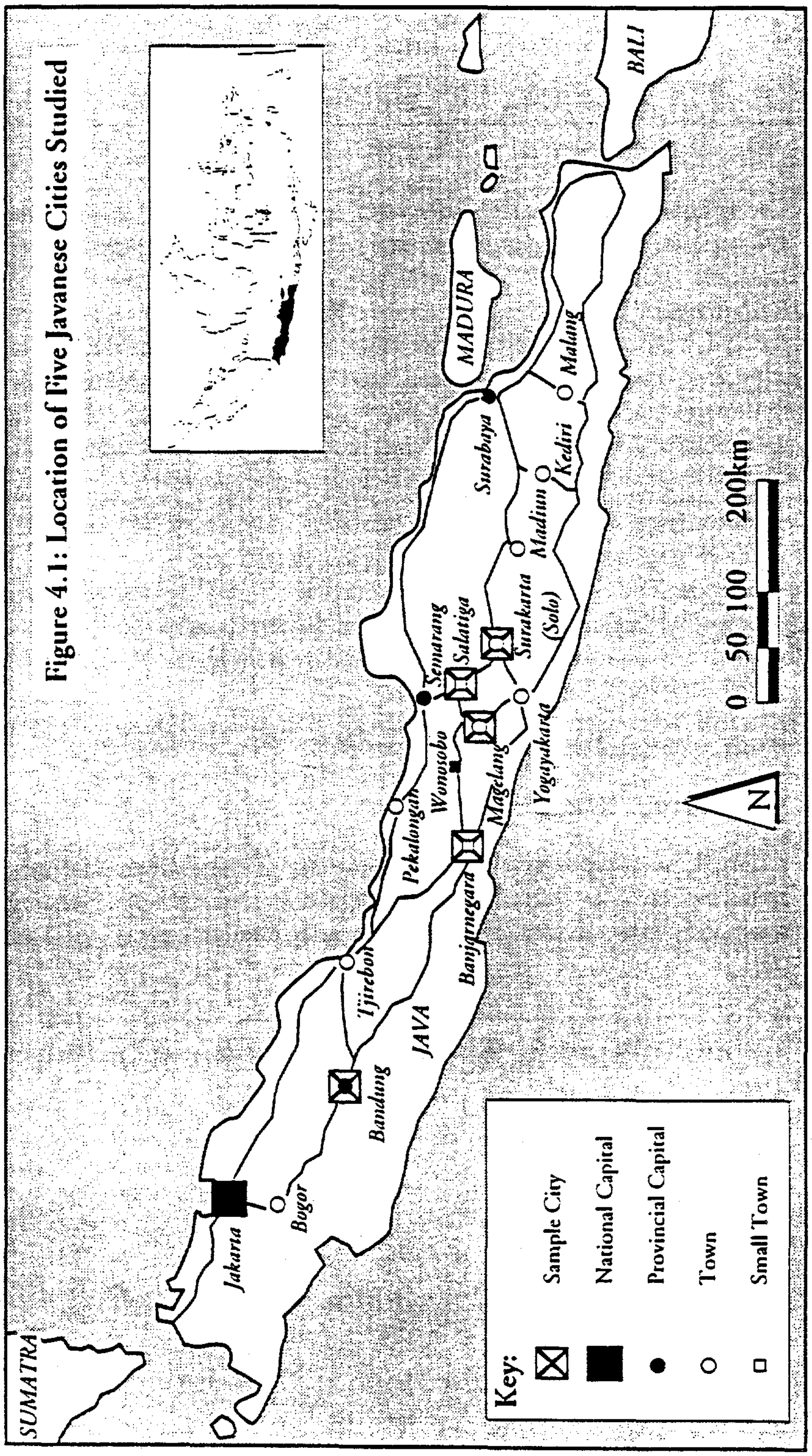


Figure 4.1: Location of Five Javanese Cities Studied

In 1988, the estimated national population of Indonesia was in the region of 170 million, approximately 142 million (83.5 per cent) of whom resided in settlements of less than 20,000; 148 million in settlements of less than 100,000 (87 per cent); 155 million in settlements of less than 500,000 (91 per cent); 158 million in settlements of less than 1 million (93 per cent); and 162 million in settlements of less than 4 million (95 per cent) (UNDP/UNCHS, 1985).

Employing the same proportions cited above to the 1990 national population estimates of 178 million, one may calculate that approximately:

- 12.5 million inhabitants reside in either conurbation or metropolitan areas;
- 16 million inhabitants reside in large cities and above;
- 23.1 million inhabitants reside in intermediate cities and above;
- 29.4 million inhabitants reside in small cities and above;
- some 140 million live in settlements with communities below the *Kelurahan* level.

These and the preceeding estimates are illustrated in Figure 4.2. The 1990 estimates cited above contrast with those of the World Bank (1992) which placed the national population of Indonesia at 178 million of whom 55 million (31%) reside in urban areas, 17.8 million live in cities of one million or more and 8.9 million live in Jakarta. The implication of these developments is that migration and population growth of the larger urban areas have significantly increased since 1988.

The largest of the five settlements visited (Bandung) has the highest annual population growth rate at 3.47 per cent, significantly higher than the other four cities (see Table 4.2). The settlements vary in their principal function from major education/manufacturing centres (Bandung) to a market town (Banjarnegara). Further differentiation may be made on the basis of the pace of growth they experience and the type of urban form configuration they adopt.

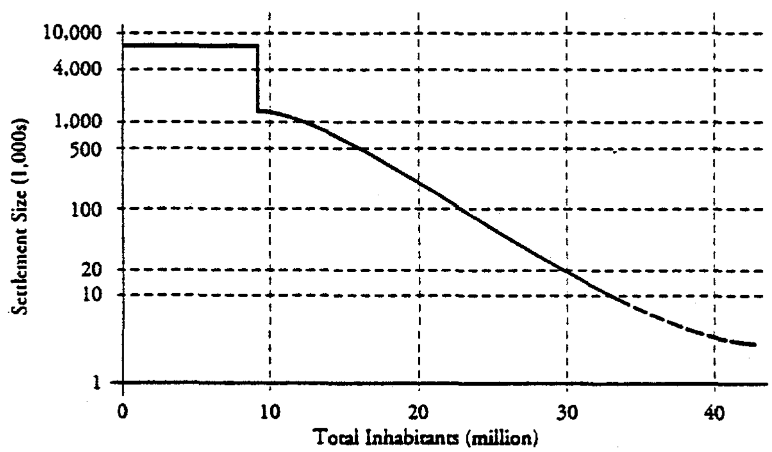
Table 4.2: Population Characteristics of Five Javanese Cities

City	Population		Official City Classification	Population Growth (pa)		Population Density [pers. per ha]
	1985	1990		1985	1990	
Bandung	1,408,700	1,810,000	Metropolitan City	3.10	3.47	174
Solo	502,200	504,176	Large City	1.87	0.71	114
Magelang	123,500	123,213	Medium Size City	1.80	0.02	68
Salatiga	84,700	98,072	Small City (A)	1.76	1.34	49
Banjarnegara	41,200	66,584	Small City (B)	1.97	1.32	27

Source: Adapted from Table 3.1, TDC S.A., 1988 and BPS, 1990

While the five cities were chosen for study as representative of each category of urban area in Indonesia (with the exception of the conurbation), their proximity to Jakarta was also taken into consideration in their selection given the location of the research team (in the capital) and the financial and time constraints placed on the team which did not permit investigations too far afield from Jakarta. Despite this, and with certain exceptions, the findings of the visits to the selected cities confirmed many of the observations noted in the literature review regarding earlier urban transport research in the country, as well as the more theoretical observations noted by Bouladon (1967a and 1967b) and Sasaki (1970). The following account seeks to explain the relevance of these findings in the five selected settlements as a background to the proposed approach for urban transport policy making and planning outlined in Chapter 5.

Figure 4.2: City Population by Settlement Size



Source: Derived from Figure 3.6, TDC S.A., 1988 and UNDP / UNCHS, 1985

Factors Affecting Urban Transport

General Considerations

Given that urban transport requirements are determined by population size, density, distribution, and other socio-economic and physical characteristics of a city (see Appendix 1), a settlement typology is developed below as a means of helping to assess transport demand.

Factors found to influence transport demand most in the sample cities are shown in Table 4.3. Close scrutiny of these factors reveals that many of the determining influences are more easily highlighted by the use of a city typology of the kind proposed below. This identifies:

- dimensions of transport demand (measured in terms of vehicular passenger/goods movement);
- the growth rate of travel demand (using the same indices of growth given above but over a given time period);
- the spatial patterns of trip-making (measured in terms of composition, frequency, length and direction of movement);
- the proportion of external to internal trips (presented as a ratio);
- the quality of the transport service on offer (measured in terms of cost, speed, comfort advantages and other levels of service indices).

This typology differentiates among settlements on two levels: firstly, according to size, structure and area; development characteristics; physical characteristics; and function; and secondly, on the basis of its transport and travel characteristics. A set of matrices are recommended on the basis of these differentiations which, among other things, act as

Table 4.3: Factors Affecting Urban Transport Demand in Indonesian Cities

Expression of Transport Demand	Influencing/Determining Factors
Demand Dimensions:	- city size (area and population) - population/city's socio-economic characteristics - population/city's major activities and kind of employment
Growth Rate of Travel Demand:	- population and per capita income growth rate of the city - development policies for city - city's function within region - city's location and accessibility with respect to major national/regional transport road network and terminals e.g. major airport, port and rail terminals - city's location with respect to proximity to large/metropolitan city - growth potential of city's hinterland
Spatial Patterns of Trips:	- city form and structure - city's transport network - area of the city - topography of city
Share of External Generated Trips:	- city's centrality (the extent of the area is served by city's own urban functions) - city's location within regional transport network
Transport Service:	- socio-economic characteristics of population - major employment structure and general income levels

Source: Table 3.5, TDC S.A., 1988

inventory frameworks for the collection, storage and analysis of important city data affecting transport, and for the formulation of policy and planning guidelines. The information logged in these matrices (see Figures 4.3 to 4.7) not only provides an insight into the dynamics of settlements as their data changes over time but also can furnish a more knowledgeable understanding of the development context in which trip-making is made and transport plans are proposed. This in turn can assist in the further development of more sensitive settlement typologies for both transport and other kinds of planning exercises than has hitherto been possible.

Settlement Characteristics

Settlement Size, Structure and Area. The community structure, composition and characteristics of the sample cities described in Chapter 2 (see Figure 4.3 and Table 4.4) indicate a relatively high level of compatibility with the more theoretical dimensions forwarded by Sasaki (1970), based on work conducted by C.A. Doxiadis (1968) (Figure 4.4).

Plotting community characteristics for each settlement against national and provincial average dimensions can provide additional useful information for planning, in that it highlights typical and atypical cities. If Sasaki's hypotheses regarding the hierarchical relationship of trip-making to community structure can be substantiated in Indonesia, then in instances of poor or absent data, the transport planner is able to substitute the trip-making factors of one settlement within a particular settlement typology and community structure with those of another.

Figure 4.3: City Data Inventory for Settlement Size, Structure and Area Characteristics

1) Settlement Size, Structure and Area	City Type						Community Hierarchy (Number)				Average Community Area [ha]					Average Community (Number)				
Character / City Name	Conurbation	Metropolitan Area	Large City	Medium City	Small City	Town	Kecamatan	Kelurahan	Rukun Wargas	Rukun Tetanggas	City wide	Kecamatan	Kelurahan	Rukun Wargas	Rukun Tetanggas	City wide	Kecamatan	Kelurahan	Rukun Wargas	Rukun Tetanggas

Source: Figure 3.8, TDC S.A., 1988

Table 4.4: Population and Community Characteristics of five Javanese Cities

City	Total Population 1985	Administration and Structure: Number of Communities				Average Population Size per Comunity			
		Kec	Kel	Rw	Rt	Kec	Kel	Rw	Rt
Bandung	1,408,700	16	91	837	5833	88,041	15,480	1,683	241
Solo	502,200	5	51	176	1976	100,431	9,846	2,853	254
Magelang	123,500 (1)	2	11	117	973	61,710	11,220	1,055	127
Salatiga	84,700	1	9	70	494	84,651	9,406	1,209	171
Banjarnegara	41,200 (2)	1	11	N/A	N/A	41,199	3,745	N/A	N/A

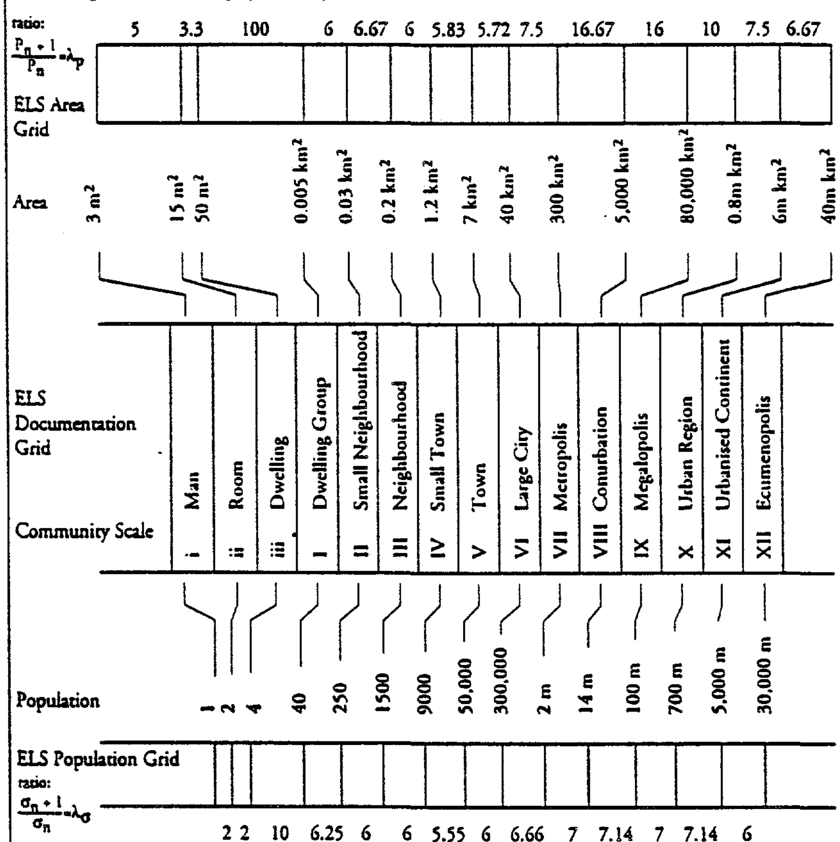
(1) 1984 Data
(2) 1986 Data

Key:
- Kec Kecamatan
- Kel Kelurahan
- Rw Rukun Warga
- Rt Rukun Tetangga

Source: Adapted from Table 3.2. TDC SA. 1988

Figure 4.4: Doxiadis Ekistic Human Settlement and Community Classification

Ekistic Logarithmic Scales (graphic interpretation)



Source: Figure 22, Doxiadis, 1968

Settlement Development Policy. Discriminating among those settlements experiencing fast, average or slow rates of growth - measured in terms of population, per capita income and urban land development growth - is another feature of the proposed city typology, as is the distinction between those cities pursuing different development policies (e.g., centralised, decentralised and laissez faire growth policies) in response to these growth trends (see Figure 4.5). Such distinctions lead to a better idea of the quantitative and qualitative pace and direction of development.

The advantage of this approach is that transport planning methodologies which take into account these factors are less likely to be subject to the bias of urban transport planning practices which typically address 'fast growing' situations and deal less well with the realities of a slower pace of growth of many other predicaments.

Unfortunately, very little information regarding the above development indices (of household income and levels of governmental decentralisation) was forthcoming in the sample cities. What is encouraging from the preceding chapter, however, is that despite this, current IUIDP policies in Indonesia have now made the provision of such data a prerequisite to the assessment of its effective programme implementation. A more detailed discussion concerning these aspects as they relate to the sample cities is given in Appendix 1.

Figure 4.5: City Data Inventory Framework for Settlement Development Characteristics

2) Settlement Development & Characteristics	City Type						Growth Parameters									Development Indicators				
							Population			Urban Land			Per Capita Income			Household Income			Degree of Decent	
Character / City Name	Conurbation	Metropolitan Area	Large City	Medium City	Small City	Town	Fast	Average	Slow	Fast	Average	Slow	Fast	Average	Slow	Low	Medium	High	De-centralisation	Centralisation

Source: Figure 3.9, TDC S.A., 1988

Urban Form, Density and Topography. Past urban and transport planning practices have typically failed to select and promote transport technologies on the basis of their ability to encourage more favourable urban form patterns, densities and structures that are compatible with local topographical constraints. In this regard, the sub-categorisation of the proposed settlement typology in terms of its physical characteristics is a very important basis for the selection of preferred urban transport technology mixes at the policy making stage.

The typology of physical settlement characteristics proposed in Figure 4.6 differentiates among cities on the basis of city area size, urban form pattern, average density and topography. Details of these characteristics in the sample cities indicate that the three smallest settlements (Magelang, Salatiga and Banjarnegara) possess a linear urban form, typical of ribbon development along arterial roads in Indonesia. Also of interest, is the fact that the land area of Bandung, given its population size, is especially small in comparison with other settlements because much of the settlement's more recent urban growth has taken place outside of the city's boundaries. As these city boundaries are 'artificially' limiting, the area size cited earlier is not an accurate reflection of Bandung's true physical expanse. Further discussion regarding the urban form, density and topography observations of the sample cities is given in Appendix 1.

Figure 4.6: City Data Inventory for Physical Characteristics

3) Physical Settlement Characteristics	City Type						Urban Form Pattern					City Size [km squared]			Density [pers/ha]			Topography			
Character / City Name	Conurbation	Metrop. Area	Large City	Medium City	Small City	Town	Linear	Concentric	Grid - Iron	Combined	Other	Large	Medium	Small	High	Medium	Low	Hilly	Undulating	Flat	Other

Source: Figure 3.10, TDC S.A., 1988

Settlement Function. Of all the limitations of conventional urban transport planning practice, perhaps the most serious has been its inability to take adequate account of the differences in settlement development functions and land use dynamics, preferring instead to focus on traffic flow and congestion issues. The new approach advocated here addresses this problem by investigating the main functions, dominant land usage and principal employment of settlements as part of the city typology cited in the NUDS Study (UNDP / UNCHS, 1985) (see Figure 4.7).

Common to all the sample cities is that each plays an administrative role for their hinterland, though at markedly different levels of governance. The three largest settlements - Bandung, Solo and Magelang - are industrial and manufacturing centres, while Bandung, Solo and Salatiga are significant tourist centres. Bandung, Magelang and Banjarnegara incorporate residential areas for the military. Residential land use comprises more than 50 per cent of the total land area in the sample cities. Further details of settlement function characteristics of the sample cities are given in Appendix 1.

Travel and Transport Characteristics

Transport Inventory. Since most urban transport problems in Indonesia are associated with issues of matching (or the inability to match) the demand for transport with its supply (see Chapter 2), an attempt to identify typical travel demand and supply characteristics of particular city types on a nation-wide basis is important in order to arrive at more

Figure 4.7: City Data Inventory for Settlement Function

4) Settlement Function	City Type						Principal Function							Dominant Landuse [%]						Dominant Employment						
Character / City Name	Conurbation	Metrop. Area	Large City	Medium City	Small City	Town	Administrative	Indust/Manuf	Educ/Culture	Market	Military Resid.	Tourism	Other	Resid/Devtial.	Commercial	Industrial	Military	Undeveloped	Other	Civil/Military	Student/Educ.	Industry	Commerce	Services	Agriculture	Other

Source: Figure 3.11. TDC S.A., 1988

sensitive planning responses. To assist in this exercise, it is crucial to compile a standardised inventory of basic transport infrastructure and services with back-up information regarding the performance of the transport systems in operation. From an assessment of these two sets of data, one can then more readily identify problems and establish whether there is a relationship between the identified problems and the type of settlement in which they are found.

Observations in the field suggest that an inventory of urban transport facilities of the kind shown in Figure 4.8 can be relatively easily compiled. Such an inventory focuses on basic information concerning the road network, transport services, and travel patterns - with travel patterns representing a manifestation of the use of the transport network and services.

Regarding the road network itself, information on the following aspects is likely to prove valuable as a basis for transport planning:

- road network configuration, differentiated in terms of road network pattern (i.e., linear, radial, concentric, grid iron or combined);
- road network functional hierarchy, differentiating among artery, collector and local roads etc., and the level of completeness of the hierarchy;
- road network classification, differentiating among the legal status and agency responsibilities of the various routes;
- the quality of the road network, indicated by the condition and surface of the roads, differentiating among good, fair and bad conditions, and among asphalt, dirt or other surfacing.

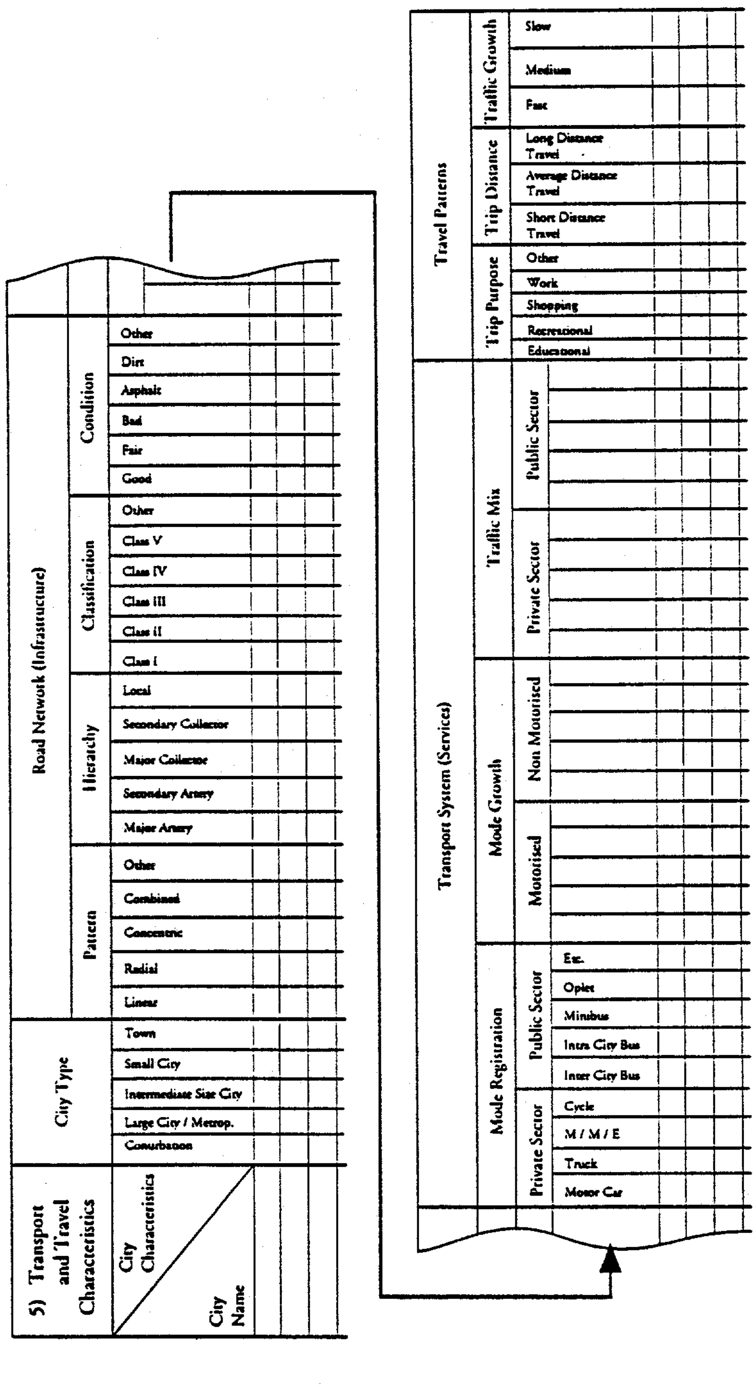
With regard to urban transport services, similarly useful data includes:

- registration/licensing of transport services by mode, operational characteristics, and private and public sector ownership and organisation;
- growth of transport services of a motorised and non-motorised kind operated both by the public and private sector;
- the quality of the service on offer, differentiating between the level of service provided, and the accessibility offered to the population by type of public transport vehicle, public transport route, and by proximity and linkage to national and regional transport networks.

Travel Patterns. Regarding travel patterns, valuable data on these aspects include details of:

- dominant trip purpose, disaggregated in terms of public and private transport, and motorised and non-motorised travel;
- trip distances, disaggregated in terms of public and private transport, and motorised and non-motorised travel; and
- traffic growth disaggregated in terms of public and private transport, and motorised and non-motorised travel.

Figure 4.8: City Data Inventory for Basic Transport and Travel Characteristics



Source: Figure 3.12, TDC S.A., 1988

What was noted from the field data collected is that very little information is available regarding city-wide transport services and travel patterns, whereas much more data exists concerning the provision of transport infrastructure, particularly along specific routes and corridors. This is typical of all Indonesian cities, and emphasises the superior databases often available to engineers in comparison to planners.

Road System and Traffic Growth. An examination of the road systems, and the growth and dominant composition of traffic in each of the sample cities suggests that Indonesian cities may be differentiated according to whether they possess the following road infrastructure:

- simple road systems whose traffic is not anticipated to grow in the near future;
- simple road systems whose traffic is anticipated to grow rapidly in the near future;
- complex road systems which face severe congestion with traffic that is anticipated to grow rapidly in the near future.

The first of the above is typical of some small and intermediate sized settlements which experience relatively slow population growth rates, largely because of their inaccessibility and/or because of their lack of proximity to an important economic resource. None of the settlements visited, however, fell within this category.

Typical of those cities with simple road systems and whose traffic is anticipated to grow rapidly in the near future, are small and intermediate sized settlements, such as Salatiga and Magelang, whose traffic and population growth is expected to increase significantly as a result of the following factors:

- newly developed local resources attracting capital and migration;
- external considerations, such as the assignment to the city of a national/regional administrative or economic role;
- the recent location of a major national/regional transport terminal (such as an airport) in its proximity.

Those cities, such as Bandung and to a lesser extent Solo, with more complex road systems, face more widespread and severe traffic congestion. They are anticipated to grow rapidly in the near future, thus presenting the most challenging problems. Traffic problems originate from any one or a combination of the following:

- growing national and/or regional development functions whose congestion problems result from a rapidly growing hinterland;
- external influences such as improved access to the city by virtue of improved national and regional transport network access;
- the internal structure of the city, and the mis-match of its transport

infrastructure and services to the land use and economic activities it hosts.

Transport Modes and Traffic Mix. The above typology may be further differentiated in terms of highlighting the difference among settlements in which:

- city-wide pedestrian and non-motorised movement is still important, as in the case of Banjarnegara and Salatiga;
- motorised and non-motorised transport systems play an equally important role, as in Magelang;
- motorised transport plays a dominant role (while non-motorised movement only serves local areas and communities), as in Bandung and to a lesser extent Solo.

In all cases, measures of the traffic mix problems may be determined by examining the percentage share of local to through traffic; the ratio of freight to passenger movement; the size of the city; and the dominant economic functions of the settlement - each in relation to predetermined standards.

Matching Transport Systems and Settlement Hierarchy

Transport Systems and Settlement Hierarchy

Urban Communities. The fact that Indonesian cities, as indicated in Chapter 3, are administratively divided into large communities (*Kecamatans*), which are in turn sub-divided into smaller 'urban village communities' (*Kelurahans* and *Rikan Wargas*) - and sub-divided again into neighbourhoods (*Rukun Tetanggas*) (see Table 4.4), provides a particularly good opportunity for testing the validity of Sasaki's (1970) thesis and the relevance of Bouladon's (1967a and 1967b) premise regarding the mis-use of transport modes in urban areas.

Transport modes operating in the five Javanese settlements visited are discussed below and in Appendix 2 with a view to assessing their utility, and mechanical and economic performance, and to establish how they can be better mobilised in the service of both present and future patterns of travel demand. The nature of this travel demand is first examined as a function of the community structure in order to gain an insight into the best way of rationalising such transport services and related infrastructure provision.

Urban Communities and the Road Hierarchy. While the population density of the *Kelurahan* varies considerably among the settlements visited - from a minimum of 20 people per hectare in the smaller settlements to as many as 500 people per hectare in the high density areas of the largest city - these communities have nevertheless a number of observable common characteristics in terms of their physical infrastructure.

They typically consist, for example, of single-storey houses, mostly of light-weight construction with their immediate vicinity served by narrow walkways (*jalan tikus* - literally translated as 'rat-ways') (see Figure 4.9 and 4.10). These walkways are mostly unpaved and only wide enough for pedestrian and two-wheeled vehicle movement and generally represent a shared use of the private land that goes with each house. Next on the road hierarchy are footpaths of 1.0 to 2.0 metres width, again only able to accommodate pedestrians and two-wheeled vehicles (see Figure 4.11). Community roads with widths of 2.5 to 4.0 metres come next and are usually sufficiently wide to allow two *becaks* to pass each other (see Figure 4.12). Some such roads are wide enough for four-wheeled motorised vehicles but access to them is dangerous because of competing pedestrian and non-motorised use (see Figure 4.13). These roads generally connect with 'local roads', serving four-wheeled motorised traffic (see Figure 4.14).

Local roads in the sample cities typically accommodate motorised traffic, especially from the intermediate sized settlements and above, and attract ribbon development of middle income housing, as well as

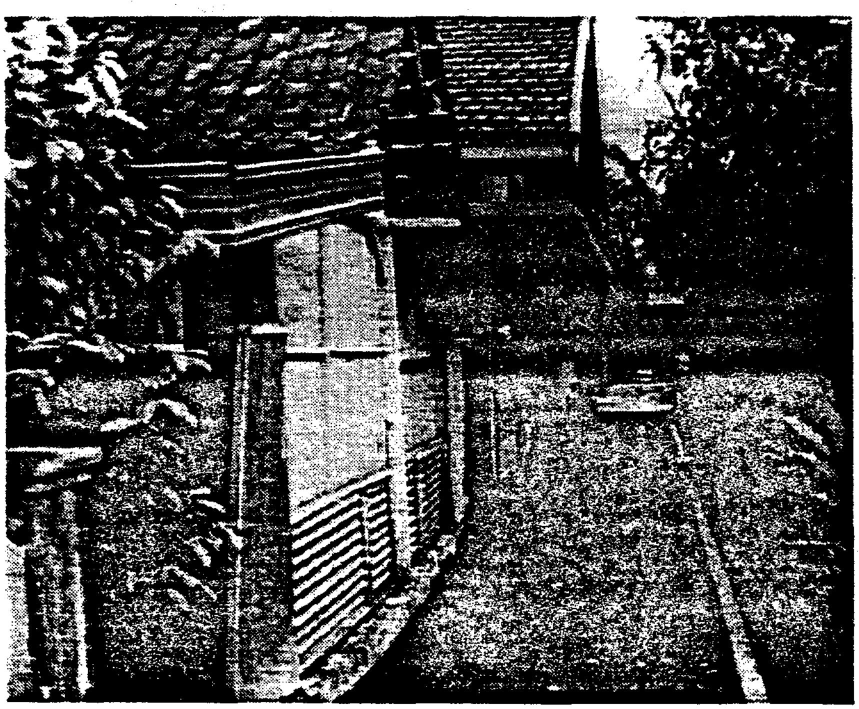


Figure 4.9: Jalan Tikus in an urban community in Bandung

Figure 4.10: Jalan Tikus in Kampung Pelesiran, Bandung, used as a motorbike parking area and chicken coop storage

Figure 4.11: An example of foot-paths in an urban community of Bandung

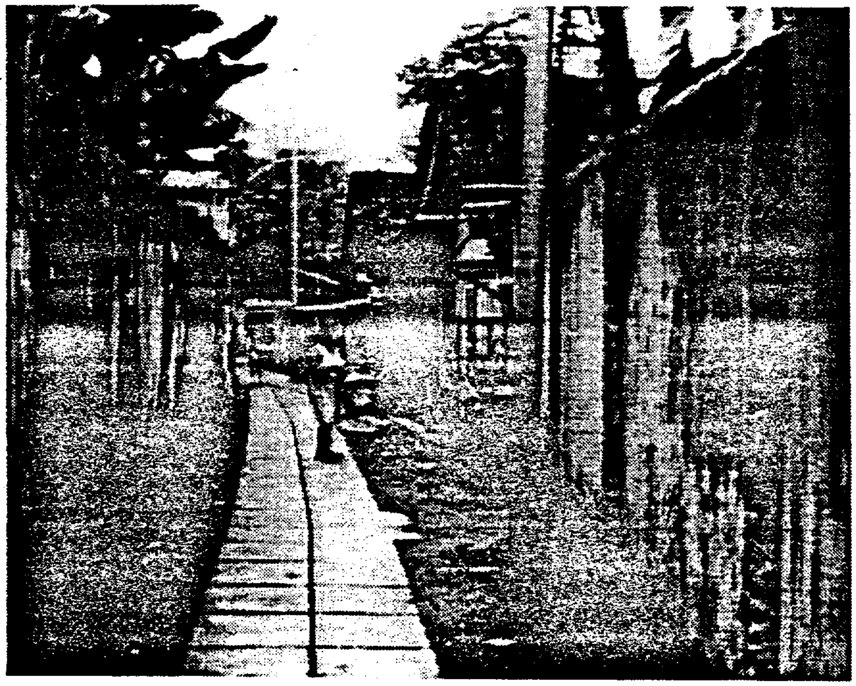


Figure 4.12: A community road at Kelurhan Maleber, Kecamatan Andir, Bandung

Figure 4.13: Poor pedestrian facilities in Solo

various associated economic activities. These activities include shops, eating establishments, vehicle repair workshops etc., behind which are lower-income dwellings to which access is provided by way of narrower community roads (see Figure 4.14). Small shops serving food (*warungs*) exist along many of the narrow community roads (see Figure 4.15). Small scale economic activities on the other hand, also frequently cluster around junctions of footpaths with the local road. Such junctions are commonly used to serve as 'pick-up' and 'set-down' points of informal motorised public transport services (see Figures 4.16 and 4.17), and as such act as important transport focal areas around which *becaks* cluster and fulfil a feeder function.

In a more conventionally planned road hierarchy, movement needs would generally predominate over the needs of access - the efficiency of the road system being achieved through the specialisation of function (this being the hierarchy's main purpose). It is clear from field observations, however, that the use of roads does not always follow their assigned function (see Chapter 3). This is especially apparent in the larger cities such as Bandung, Solo and Magelang where the roads providing collector and artery functions are insufficiently wide and are subject to both inappropriate access regulations and modal conflict.

Hierarchy of Urban Activities and Services. The confirmation that the sample cities contain a hierarchy of activities and services commensurate with the community to which they belong was one of the most important of the field observations. It was noted that the central business

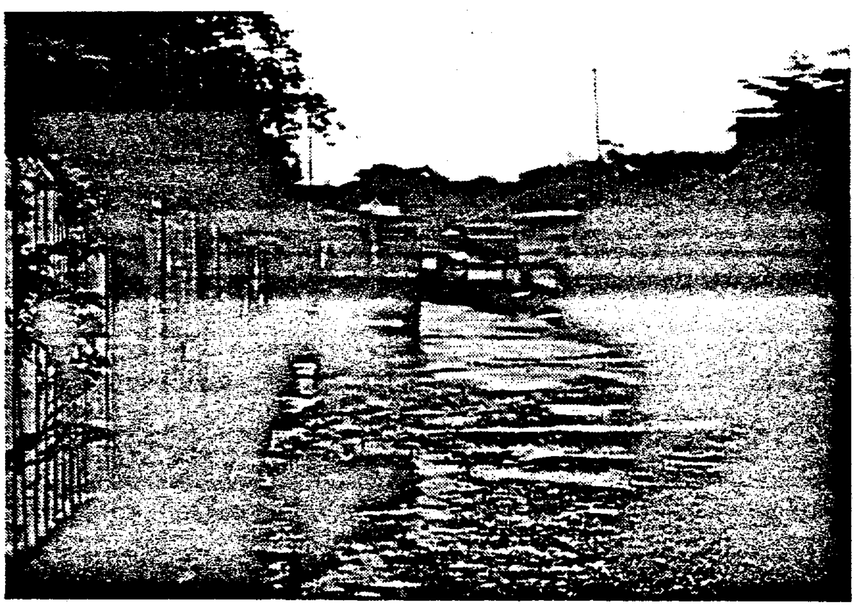


Figure 4.14: Jl. Kebon Bibit, a local road at Kelurhan Tamansari, Bandung

Figure 4.15: Warung along a narrow road within kampung area in Solo

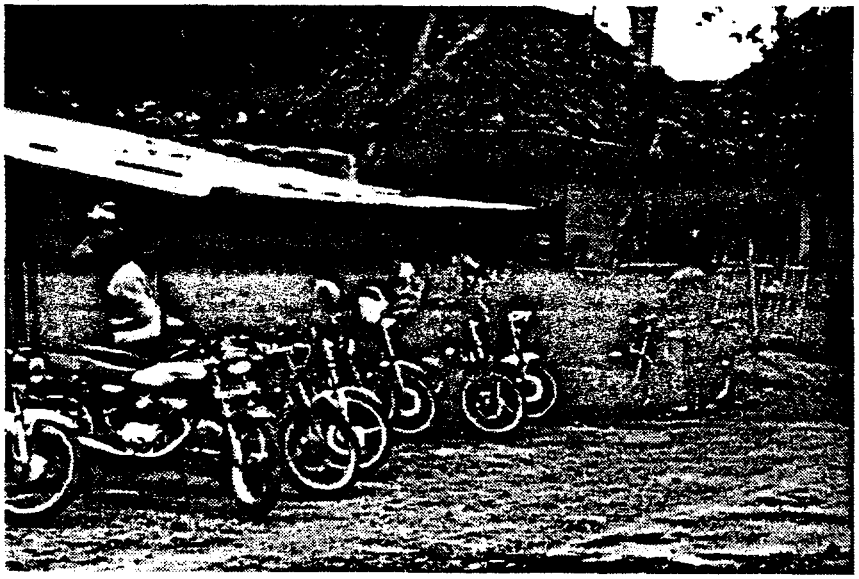


Figure 4.16: Ojeks in kampung area in Kelurahan Ujung Berung, Bandung

district (CBD), other urban sub-centres, community centres, local shopping streets, village markets, neighbourhood stores and *warungs* - all reflect such a hierarchy. These centres are characterised by a descending degree of specialisation, where day-to-day household needs are served at the 'urban village community' level, and more specialised items (as well as higher cost capital goods) are found at higher levels of the community hierarchy.

Educational facilities also follow a similar hierarchical pattern, whereby the schools attended by the largest number of children (i.e., primary school and playgroup institutions) are often found at the 'urban village community' level or even lower, with the middle and high-school usually generating trips outside the *Kelurahan*. Tertiary education establishments typically correspond to the city level and often attract/ generate cross- town trip-making.

An examination of local health services in the sample cities were also seen to follow a similar hierarchy to educational facilities, with the community health centre (*Pos Yandu*) present in every *Rukun Warga* community. There are, on average, five *Pos Yandu* in every Kelurahan supporting health workers at the neighbourhood level. The *Pos Yandu* is, in turn, supported by the smaller clinics (*Uskesmas*) at the *kecamatan* level, with more specialized health facilities provided at the city level.

Figure 4.17: A cluster of becaks near the city centre of Magelang

This observed hierarchical structure of services and activities together with the trips they generate, provides additional confirmation of Sasaki's (1970) premise that trip purposes, corresponding to more frequent day-to-day family requirements, require shorter trips than those that relate to less frequent needs. Based on these observations, together with average community size yardsticks advocated by Sasaki (1970), calculations can be made of assumed average trip lengths associated with the community level at which the corresponding trip purposes are satisfied (see Table 4.5). These were achieved by using an average population density of 100 inhabitants per hectare and were subsequently tested by field observations.

Community-Based Travel Demand and Trip Making. Although limited, the urban travel demand data collected in the field supported the characteristics contained in Table 4.5. In the absence of detailed information for the sample cities, however, use was also made of data collected during an extensive study of traditional low cost and motorised public transport modes in Bandung (see Soegijoko, 1981) already reported upon in Chapter 3. This research indicated a relatively low average trip rate of eight per day for an average household size of six members.

Both field reports and the findings of the Bandung study suggest access to shopping facilities is generally good in Javanese cities, with more than 40 per cent of the households reported in Bandung able to reach these facilities within a radius of 0.5 kilometres (Soegijoko, 1981). The same source indicates that more than 80 per cent of households are situated within 2.5 kilometres of educational facilities but that access to places of work is relatively poor, generating trips lengths from one to five kilometres.

Table 4.5: Typical Community Size and Trip Length Characteristics in Sample Cities

Community Level or City Size	Median Population (1985)	Median Area [ha]	Typical Trip Length [km]
Rukun Tetanggas	250	2.5	0.08
Rukun Warga	1,500	15	0.19
Kelurahan	10,000	100	0.50
Kecamatan	70,000	700	1.30
Medium City	300,000	3,000	2.80
Large City	750,000	7,500	4.40

Source: p57, TDC S.A., 1988

A later study of three residential areas in the same city (Marler, 1985) indicates among other things that 71 per cent of all houses could only be reached by walking, though direct access by motorcycle was possible in most cases. This same study shows that 16 per cent of houses could be reached by *becak*; only 13 per cent by four-wheeled vehicles; and 35 per cent of the work trips were observed to take place within the same *Kelurahan*.

Information from Bandung also suggests that the use of *becaks* is more significant in the case of non-work trip purposes than for work trips, though this was suspected to be less evident in smaller cities. Observations in the other sample cities confirm the Bandung findings, namely that a strong correlation between trip distance and transport mode exists, while travel time estimates seem to be largely unaffected by either.

Relationship Between Travel, Speed and Distance. The observation of a strong correlation between trip length and speed of the transport mode used, and that travellers understandably prefer to use faster transport modes for longer trips, is reinforced by Bouladon's (1967a and 1967b) research. What it is not clear in the subsequently calculated trip distances in Bandung (see Table 4.6) is the extent to which these results reflect factors other than the traveller's speed preferences and the availability of modes of travel.

By assuming that urban travel patterns exhibit comparable mode/ distance relationships for inter-urban flows traversing the city, as well as peripheral traffic to and from its hinterland, city-wide average trip distances in the settlements visited were calculated as given in Table 4.7. The resulting estimates suggest that in the three smaller sample cities (Magelang, Salatiga and Banjarnegara) typical trip lengths do not differ greatly from each other, despite the cities' difference in size. Also apparent is that average trip-making distances still fall within the range which can be considered appropriate for non-motorised means of travel; this being an observation displayed both by the most recent data collected and other studies in Indonesia. It has been claimed subsequently (TDC S.A., 1988) that one can deduce from this that problems of motorised traffic in urban areas generally originate from inter-urban and peripheral traffic flows rather than from traffic generated within the city.

It has been argued (see TDC S.A., 1988) that it is reasonable to assume that the cost of higher speed modes acts as a deterrent to travel, and that therefore, increasing affluence and better access will shorten the above average trip distances over time. Certainly, the high correlation exhibited by the estimated results tend to reaffirm Bouladon's (1967a and 1967b) thesis that for any trip distance there is a corresponding appropriate transport mode speed and vice versa.

Table 4.6: Average Trip Distances for Particular Purposes in Bandung

Average Trip Distances by Trip Purpose

Trip Distance [km]	Trips by purpose [%]				
	Work	Education	Shopping	Home	Other
< 0.5	11.3	19.1	42.2	7.2	30.7
0.5 - 0.9	11.9	27.3	27.3	20.3	9.6
1.0 - 2.4	27.1	34.1	23.6	44.8	24.9
2.5 - 4.9	31.0	15.5	4.7	24.3	17.8
50+	18.7	4.0	2.2	3.4	17.0

Average Trip Distances by Trip Purpose

Trip Distance [minutes]	Trips by purpose [%]				
	Work	Education	Shopping	Home	Other
< 5	8.1	9.2	22.2	4.3	25.1
5 - 9	9.7	27.8	26.7	13.4	13.0
10 - 14	22.2	29.5	25.1	31.4	17.6
15 - 29	32.4	29.7	19.2	36.6	18.8
30 - 59	20.8	8.2	5.2	12.4	11.3
60+	6.7	0.6	1.6	1.8	14.2

Source: Soegijoko (ed.), 1981

Average Travel Distances By Mode

Mode	Distance [km]				
	(1)	(2)	(3)	(4)	Weighted Average
< 5	1.1	-	2.1	0.9	1.2
5 - 9	2.1	-	-	1.3	1.9
10 - 14	4.4	5.4	3.0	4.1	4.5
15 - 29	3.3	-	-	-	3.3
30 - 59	3.9	4.1	2.6	4.4	3.9
60+	4.7	6.7	-	4.6	5.2

Source: *(1) Soegijoko (ed.), 1981* — *100 Households in Bandung*
(2) ARSDS, Jakarta, 1984 — *Sample not known*
(3) Marler, 1985 — *206 Households in Bandung*
(4) Dak, 1987 — *286 Households in Bandung*

Table 4.7: City-Wide Average Through-Traffic Trip Length for Five Javanese Cities

City	City Typology	Avg. City-Wide Trip Length [km]
Bandung	Metropolitan City	9.00
Solo	Large City	3.30
Magelang	Intermediate Size City	2.10
Salatiga	Small Size City	2.10
Banjarnegara	Market Town	1.95

Source: p. 61, TDC S.A., 1988

Assessment of Transport Modes

Observed Use and Misuse of Transport Modes. The following discussion (together with Appendix 2) reviews various aspects of transport modes in operation in the sample cities. The economics of existing modes and the efficiency of their utilisation of road space under varying conditions, and the appropriateness of the trip lengths typically travelled by various modes in relation to their speed, safety and other design features, are also examined. Based on the findings of this investigation, conclusions are drawn which can assist in arriving at more cost effective designs of complementary infrastructure and possible design improvements to the modes themselves.

In order to assess the performance of transport modes in the settlements visited, and to investigate any alleged mis-use of such modes, it is first necessary to consider the performance criteria employed in making such assessments. There are at least two aspects to this assessment: one concerns the utility value of the mode to the operator and user; the second concerns the engineering efficiency of the mode, based for example on considerations of the speed/distance relationship discussed earlier and some measure of road space utilisation of the kind discussed below.

Characteristics of urban travel from the user's point of view can be judged under four main categories; namely: journey time, journey cost, physical exertion (together with degree of discomfort and risk of accident involved), and the facilities available for transporting luggage, freight and goods. Journey time, among other things, is affected by the speed of the transport mode in use, the behaviour of the mode under various conditions of traffic, the influence of road capacity limitations, the ability of the vehicle to negotiate obstacles and pavement defects, and the time involved in mounting and alighting the mode at transfer points. Journey cost, in turn, is affected by the transport mode's capital cost, fuel consumption and maintenance costs, staff salaries (in the case of public transport), as well as national and local taxes imposed on vehicle owners (including parking fees, fines for traffic violations, etc.).

The physical exertion, discomfort and risk of accident to which the transport user is exposed, is determined to a large extent by the amount of walking the journey involves (especially if this includes traversing pedestrian bridges or under-passes). It is also affected by the acceleration, deceleration, suspension and other mechanical design features of the vehicle, the ergonomics of the passenger compartment, the manoeuver-ability and stability of the vehicle on the road, the thermal insulation, ventilation and/or air conditioning of the vehicle, and (for pedestrians) any shade or rain protection provided. Finally, the luggage goods and freight carrying capacity of a vehicle is affected by the transport mode's flexibility in changing from passenger to freight carrying loads and vice versa, and the provision of luggage racks and space for locating larger items of luggage.

Urban transport modes in Indonesia are clearly operated in a way which is very different to that of industrialised countries since, with the exception of high income-group travel (which is fast rising), priority in the country is given to considerations of economy and to attaining maximum access with limited resources - usually at the expense of comfort, speed, privacy and even safety.

Performance of Transport Modes. The large number of urban transport modes in use in Indonesia has already been remarked upon in Chapter 3. In order to analyse the performance of these modes in the five settlements visited, only representative members of each of their main categories and characteristics are described in Table 4.8 (also see Appendix 2).

Mechanical and cost data of the various transport modes are shown in Tables 4.9 and 4.10 respectively. These calculations are based upon estimates derived not only from cited research papers but from information obtained through interviews with officials of the Ministry of Com-

Table 4.8: Type and Capacity of Public Transport Modes Operating in Five Javanese Cities

Transport Modes	Passenger Capacity
Private Transport Modes	
Pedestrian	1
Gerobak or Kakilima (Pedestrian with push cart)	1
Bicycle	1
Motorcycle (Honda GC)	2
Motorcar (Toyota Corolla)	5
Public Transport Modes	
Becak (Three-wheeled non-motorised pedicab specific to Indonesia)	3
Andong (Horse-drawn carriage in various sizes)	7
Ojek (Motorcycle used as a taxi)	2
Bajaj (Motorised tricycle using a 150 cc engine, steered like a scooter)	3
Bemo (Three wheeler with 360cc engine)	8
Mikrolet I (1000cc engine motorised vehicle, e.g. Hijet Zebra)	10
Mikrolet 11 (1500cc engine motorised vehicle, e.g. Toyota Kijang)	11
Minibus (3300cc engine small bus, e.g. Mitsubishi FE-114)	26
City bus (5675 cc engine bus, e.g. Mercedes)	51

Source: TDC S.A., 1988

munications (*Dinas LLAJR*) in the sample cities, and with representatives of vehicle manufacturers, owners and operators of informal sector public transport services. Costs per passenger kilometre for each of the modes cited (based on 1988 prices), with the exception of the *andong* and walking, are summarised in Table 4.10. The costs are based on estimates of depreciation, maintenance, fuel consumption and, where appropriate, the economic costs of a driver and a conductor.

An important factor in assessing mode performance not covered in the above cost calculations is that of a mode's efficiency in the utilisation of road infrastructure, i.e., the obstruction per passenger which the mode presents at different road widths and traffic flow velocities. It has been argued (TDC S.A., 1988) that a higher efficiency in this regard will result in lower traffic volumes per passenger and hence will make it possible for cities to make do with narrower roads and less disruptive traffic management measures.

On this basis, it is claimed that some measure of road utilisation of a transport mode makes an important contribution to the assessment of its true economic cost. An assessment of this kind depends on more than the surface area of the road occupied by the transport mode, since it also

Table 4.9: Indonesian Urban Transport Modes: Mechanical Characteristics

Transport Modes	Length [m]	Width [m]	Official Passenger Capacity	Extra Freight [kg]	Engine Size [cc]	Fuel Consumption [km / l]	Cruising Speed [km/h]
Private Transport Modes							
Pedestrian	1.0	0.6	1	30	N/A	N/A	5
Pushcart	2.1	0.8	1	200	N/A	N/A	5
Bicycle	1.8	0.6	1-2	50	N/A	N/A	16
Motorcycle	1.6	0.8	2	30	125	20 (S)	80
Motorcar	4.1	1.6	5	100	1290	9 (S)	100
Public Transport Modes							
Becak	2.3	1.0	3	30	N/A	N/A	10
Andong	3.5	1.5	7	100	N/A	N/A	10
Ojek	1.6	0.8	2	15	125	20 (S)	60
Bajaj	2.5	1.2	3	30	150	30 (S)	40
Bemo	2.9	1.25	8	30	360	16 (S)	40
Mikrolet I	3.8	1.8	10	70	1000	9 (S)	60
Mikrolet 11	4.3	1.25	11	80	1500	10 (S)	60
Minibus	5.4	1.9	26	N/A	3298	8 (D)	60
City bus	9.3	2.5	51	N/A	5675	5 (D)	60

Source: Table 3.10 TDC S.A., 1988 (S) = Super Fuel (D) = Diesel Fuel relies on both vehicle widths and the widths of the road. The measure, furthermore, should take into account both the mode's maximum speed compared to the free flow speed of the surrounding traffic, and the average distance between stops.

The 'road utilisation function' advocated is analogous to a passenger car unit (pcu) value for a mode which in industrialised countries is defined as a vehicle's contribution to saturated traffic flow compared to that of a standard motorcar. The 'pcu value' is normally determined empirically by measuring saturated flows with different modal mixes. Due to the fairly standard road and traffic conditions in industrialised countries, 'pcu' values are conveniently regarded as intrinsic to a transport mode and generally independent of the extraneous factors mentioned above. Its appropriacy to Indonesia is obviously more limited, therefore, except at the higher levels of the road hierarchy (2).

The results of calculating a road utilisation function for Indonesian modes at various levels of the road hierarchy in the sample cities using the data in Appendix 2 are given in Table 4.11. The results, however, need to be treated with caution, particularly at lower road widths, in view of the following two weaknesses: firstly, that the value of the function increases as a vehicle's width approaches the width of the road it is travelling on, suggesting that the difference between the road width and the vehicle width should figure in the denominator of the formula which

Table 4.10: Indonesian Urban Transport Modes: Economic Characteristics

Transport Modes	Capital Cost [m. Ep]	Useful Life [year]	Mainten. Costs [ERp./mc]	Daily Travel [km/day]	Fuel Costs [Erp./mo]	Driver & Assistant [KRp./mo]	Cost per Passenger [Rp / km]
Private Transport Modes							
Bicycle	0.15	15	2	20	0	0	6
Motorcycle	0.65	15	10	50	33	0	16
Motorcar	15.0	8	30	50	73	0	35
Public Transport Modes							
Becak	0.70	8	5	20	N/A	75	69
Ojek	0.65	10	15	100	66	75	54
Bajaj	3.00	5	20	70	31	100	48
Bemo	5.00	8	25	70	58	100	18
Mikrolet I	13.50	8	35	100	147	275	22
Mikrolet 11	16.50	8	50	100	132	275	21
Minibus	31.00	10	75	100	75	275	10
City bus	80.00	12	100	100	120	300	8

Source: Table 3.11 TDC S.A., 1988

at present it does not; and secondly, that the function appears to underestimate the disruption offered by a slow transport mode on a fast road.

Applying these 'utilisation function' results to the highest class of urban road in Indonesia (Class I road) indicates that the greatest obstruction is provided by the bicycle, *becak*, motorcycle and *bajaj*. This provides a rationale for banning these modes from such routes - at least in the larger cities of say, 500,000 inhabitants and above. Another interesting finding is that the next highest obstruction per passenger is presented by the private motorcar, which is eight times as great as the city bus (a conclusion confirmed by Linn [1983]).

While the derivation of a more appropriate road area utilisation function for Indonesian urban areas is beyond the scope of this book, it is felt that an improved and properly calibrated formula for this purpose would provide urban and transport planners alike with a useful tool in calculating road capacity and designing infrastructure, especially at the local and community road level. It also provides a means of identifying the traffic levels at which modal conflicts become critical.

Transport Modes to be Encouraged. The above discussion and recorded observations indicate that the hierarchy of urban public transport modes shown in Figure 4.18 is most able to cope with the full range of travel demand in Indonesian cities.

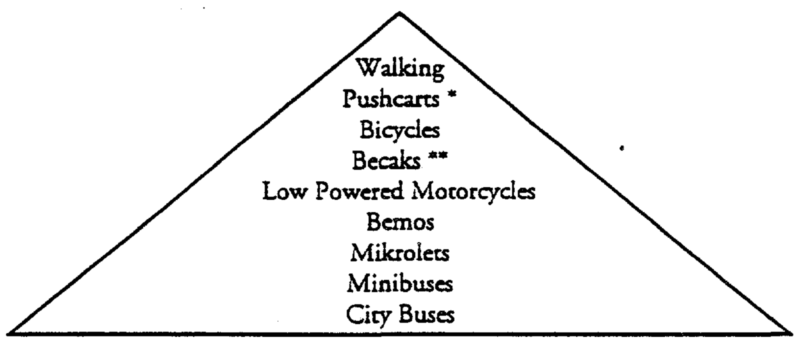
Table 4.11: Passenger Road Utilisation Functions for Various Modes by Road Hierarchy in Indonesia

Transport Modes	Foot-path	Village Road	Local Road (Class IV)	Second. Collector (Class III)	Second. Artery (Class II)	Primary Collector (Class I)	Primary Artery (ClassI/TypeI)
Width [m]	1.5	3.5	5.0	8.0	10.0	14.0	14
Design Speed	5	15	30	40	60	60	100
Pedestrian	4.10	0.70	0.40	0.30	-	-	-
Bicycle	5.70	1.10	0.60	0.30	0.30	0.20	-
Becak	5.30	0.90	0.40	0.20	0.16	-	-
Motorbike	3.80	0.70	0.40	0.20	0.17	0.14	-
Bajaj	-	1.30	0.70	0.30	0.20	0.16	-
Bemo	-	0.50	0.20	0.11	0.08	0.05	-
Motorcar	-	-	0.40	0.19	0.13	0.09	0.08
Mikrolet	-	-	0.30	0.13	0.09	0.05	-
Minibus	-	-	0.14	0.06	0.04	0.02	-
City Bus	-	-	-	0.05	0.03	0.01	0.01

Source: Table 3.12 TDC S.A., 1988

The transport modes found to be inappropriate to a local urban role include *andongs* and other animal drawn modes (except in small rural towns where there are still few motorised modes operating); high powered motorcycles; *bajajs* (except in towns with a steep topography); and motorcars. Transport modes to be encouraged may be arranged into four speed bands as shown in Table 4.12. These speed bands may then be matched to the road hierarchy of Indonesian cities as shown in Table 4.13.

Figure 4.18: Proposed Hierarchy of Public Transport Modes in Indonesian Cities



* Gerobag or Kakilima
** Substituted by bajajs where road gradients make becaks inefficient

Table 4.12: Speed Bands for Urban Transport Modes in Indonesia

Speed Band (Range 1-4)	Speed Range (kms/hr)	Transport Mode
Speed Band 1	About 5	walking / pushcarts
Speed Band 2	10-20	bicycle / becak
Speed Band 3	25-40	bemo / bajaj / low power motorcycle
Speed Band 4	50-100	mikrolet / minibus / city bus / motorcar

Source: p. 75 TDC S.A., 1988

What emerges from this analysis however, is the need to investigate the cut-off levels at which traffic in the various speed bands require segregation. Further research is also needed into transport infrastructure at the community level for various trip purposes and trip lengths, with special focus on the needs of pedestrians, non-motorised modes, and motorcycles. Particular attention should also be given to the collection of quantitative data to enable cost-benefit and economic rate of return calculations to be carried out. This would facilitate the nationwide standardisation of appropriate design details for pedestrian and non-motorised infrastructure for the following:

- standard drainage ditches;
- low cost footpaths and community roads of various widths (appropriate to the smooth riding surface and light wheel loads of bicycles, *becaks*, pushcarts, etc.);
- waiting areas for *becaks* at intersections of community roads and urban village roads;
- stopping places for mikrolet and minibuses;
- low cost sidewalks for pedestrians and pushcarts;
- low cost bikeways for bicycles, *becaks* and animal drawn vehicles;
- standard intersection designs incorporating pedestrian and bikeway crossings;
- standard details for communal areas to accommodate *kakilimas* and food vendor's stalls, etc.

Table 4.13: Matching Speed Bands with Urban Road Hierarchy in Indonesia

Speed Band (Range 1-4)	Road Hierarchy/Infrastructure
Speed Band 1 uses only:	Sidewalks along any kind of road Pedestrian bridges, pedestrian crossings, and narrow footpaths (less than 1.5m wide) in densely populated residential areas
Speed Bands 1 & 2 share:	Community roads (2m to 4m wide), Low density bike lanes (where there is no footpath)
Speed Band 2 use:	Bike lanes and bike lane crossings
All Speed Bands share:	Local roads with very low traffic volumes
Speed Bands 2,3 &4 share:	Local roads with footpaths
Speed Bands 3 & 4 share:	Indonesian Class III roads
Only Speed Band 1 uses:	Indonesian Class I and II roads

Source: p. 75 TDC S.A., 1988

Settlement Typology and Transport Problems

Over and above the urban transport problems identified nationwide in Chapter 3, a number of other issues were highlighted during the visit to the five Javanese cities. The most important of these are outlined below - some of which are common to all the settlements and others are specific only to particular cities (see Table 4.14a-c). Further settlement typological differentiation can therefore be arrived at on the basis of the transport and traffic problems encountered as the ensuing discussion suggests.

Common Problems. Indecision among authorities in response to legislation changes and study proposals for urban transport is one of the most commonly encountered problems of Indonesian cities. For example, in the late 1980s, legislation was introduced by the Ministry of Communications which was designed to clarify the functional classification of urban roads. It was at the time almost universally regarded as unhelpful, failing to lead to a more meaningful urban road hierarchy; and was therefore ignored by most local authorities.

Also common to many cities, and all the sample cities, is the problem of each city employing its own geometric design standards for different road types, even though ostensibly they are derived from common national standards. Another problem is the matter discussed at some length in Chapter 3 of how best to re-direct revenue currently derived from the local urban transport sub-sector (such as parking fees) to city related agencies and their activities in the provision and maintenance of transport infrastructure. Associated with this, is the dilemma of what action to take in both the short and long term with regard to the funding of transport infrastructure projects (such as road widening) for which there is a widespread lack of municipal funding.

Problems Specific to Particular City Types. Transport problems observed in the smaller settlements visited (see Table 4.14a) correspond very closely with those outlined in Chapter 3. They can be subdivided into the following three categories:

- the inadequate provision of infrastructure for pedestrian and non-motorised needs (especially at the 'urban village community' level);
- conflict between local and inter-urban traffic flows (and the inadequacy of city-funded road infrastructure to cope with the latter);
- the presence of inadequate roads to accommodate peripheral traffic flows, especially just beyond the city boundary.

In small and intermediate sized cities such as Banjarnegara and Salatiga respectively, the mis-match of public transport modes to city size and road hierarchy is particularly apparent. Field studies indicate

Table 4.14a: Settlement Hierarchy and Related Transport Problems in Indonesia

Road Infrastructure Problems	Transport Service Problems	Planning / Management / Maintenance Problems
A. Small Cities		
1. Inadequate facilities for non-motorised travel. 2. Insufficient good roads. 3. Poor road reserve arrangements & building set-backs on through roads (I). 4. Inadequate key access roads to local communities for multi-mode access (G). 5. Mis-match of functional road classification with their capacities (G).	1. Insufficient public transport services at affordable price. 2. High operating costs of vehicles due to poor road conditions.	1. Inadequate road maintenance. 2. Location of major traffic generators near busy intersections. 3. Poor traffic enforcement. 4. Inadequate public transport regulation (I). 5. Manpower shortages in management and technical functions (G). 6. Poor integration/co-ordination of agencies in sub-sector at local level and between central/local tiers of government (G).
B. Intermediate Size Cities		
1. Road widening requirement for through road traffic routes 2. Inadequate/incomplete network of artery and local roads 3. Scope of road improvement programme too limited 4. Inadequate key access roads to local communities for multi-mode access (G) 5. Mismatch of functional road classification with their capacities (G) 6. Poor road reserve arrange and building set backs on through roads (S). 7. Inadequate road and pedestrian facilities servicing those who's journey to work take place in same locality as their residence (G)	1. Insufficient public transport services. 2. Rapid growth in motorcycle ownership and use in excess of rate of additional infrastructure provision (L, M,C) 3. Rapid growth in motorcycle ownership and use in excess of rate of additional infrastructure provision (G)	1. Motorised traffic congestion in central areas, market areas and near major traffic generators (L, M & C) 2. Insufficiently integrated public transport traffic management and regulation 4. Manpower shortages in management & technical functions (G) 5. Insufficient regulations concerning operation of informal public transport operation 6. Poor integration/co-ordination of agencies in sub-sector at local level and between central/local government tiers (G) 7. Incursion of street vendors on main routes and footpaths reducing infrastructure capacities of major throughways (L, M & C) 8. Inadequate public transport regulation (S)

Key:
G = General Problems
C = Problems also found in Conurbation areas
M = Problems also found in Metropolitan cities
L = Problems also found in Large cities
I = Problems also found in Intermediate sized cities
S = Problems also found in Small cities

Source: Table 3.6TDC S.A., 1988

Table 4.14b: Settlement Hierarchy and Related Transport Problems in Indonesia

Road Infrastructure Problems	Transport Service Problems	Planning / Management / Maintenance Problems
C: Large Cities		
1. Inadequate road and pedestrian facilities servicing those whose journey to work take place in same locality as their residence (G) 2. Rising rapid demand on periphery for new transport infrastructure facilities (M & C)	1. Too many walk trips of lengths in excess of what is efficient by this mode of travel 2. Excessive obstacles to the efficient movement of freight transport (I, M & C). 3. Rapid growth in motorcycle ownership and use in excess of rate of additional infrastructure provision (G) 4. Rapid growth in motorcar ownership and use in excess of rate of additional infra-structure provision (M & C) 5. Physical inaccessiblility of public transport services to significant sections of the community (M & C) 6. Rising demand for public transport in face of recent policy movements to reduce government subsidies to this area 7. shortage of intra-urban bus services affordable to low and middle income groups (I, M & C) 8. Inadequacy of minibus feeder services supporting main bus routes (I, M & C)	1. Additional land requirements for increased on-street and off-street parking of motorcars and motorcycles (M & C) 2. Absence of up-to-date/completed land-use/transport plan and O&D survey (M & C) 3. Under-capitalisation/finance and declining quality of public sector bus operations (I, M & C)

Key:
G = General Problems
C = Problems also found in Conurbation areas
M = Problems also found in Metropolitan cities
L = Problems also found in Large cities
I = Problems also found in Intermediate sized cities
S = Problems also found in Small cities

Source: Table 3.6 TDC S.A., 1988

Table 4.14c: Settlement Hierarchy and Related Transport Problems in Indonesia

Road Infrastructure Problems	Transport Service Problems	Planning / Management / Maintenance Problems
D: Metropolitan Areas		
1. Inadequate road and pedestrian facilities servicing those who's journey to work take place in same locality as their residence (G).	1. Too many walk trips of lengths in excess of what is efficient by this mode of travel.	1. Additional land requirements for increased on-street and off-street parking of motorcars and motorcycles (M & C).
2. Rising rapid demand on periphery for new transport infrastructure facilities (L & C).	2. Excessive obstacles to efficient movement of road freight transport (I, L & C).	2. Absence of up-to-date/ completed land-use/transport plan and O&D survey (M & C).
3. Heavy wear and tear on particular corridor facilities and subsequent need for corridor road improvements plus new facilities.	3. Rapid growth in motorcycle ownership and use in excess of rate of additional infrastructure provision (G).	3. Uncontrolled ribbon development along major routes leading out of city on periphery (G).
4. Incomplete/inadequate road by-pass facilities (I & L).	4. Rapid growth in motorcar ownership and use in excess of rate of additional infrastructure provision (L&C).	4. Under-capitalisation/finance and declining quality of public sector bus operations (I, L & C).
5. More widespread road network maintenance and congestion problems (L & C).	5. Physical inaccessibility of formal sector public transport services to significant sections of the community (L & C).	5. Multi-nuclear employment concentration, traffic generators and subsequent longer distance travel.
	6. Rising demand for bus public transport services against backcloth of government policy movements to reduce subsidies to this area (I, L & C).	6. Poor integration/co-ordination of agencies in sub-sector at local level and between central/local government tiers (G).
	7. Shortage of intra-urban bus services affordable to low and middle income groups (I, L & C).	
	8. Need for high occupancy/exclusive lane public transport mode along certain Corridors (C)	
	9. Inadequacy of minibus feeder services supporting main bus routes and general poor integration of public transport services (I,M C)	
	10. Increasing marginalisation of non-motorised transport (L & C)	

Key:
G = General Problems
C = Problems also found in Conurbation areas
M = Problems also found in Metropolitan cities
L = Problems also found in Large cities
I = Problems also found in Intermediate sized cities
S = Problems also found in Small cities

Source: Table 3.6 TDC S.A. 1988

that *mikrolets* and minibuses in these contexts fulfil a particularly useful function - mainly related to peripheral flows linking the city with its hinterland (see Figure 4.19) - while larger buses serving inter-urban needs (along primary arteries) typically serve a large proportion of commuter traffic demand.

Observations in the five Javanese sample cities suggest that the approximate population size cut-off point which indicates the onset of motorised traffic problems lies at the 150,000 population mark. It should be stressed however, that while this finding supports the observations discussed in Chapter 3, all sample cities had common features not necessarily shared by comparable cities nationwide; namely, they are all traversed by primary arteries of the national road hierarchy which contributes to a particular set of transport problems typical of locations where local and national transport systems interface. Traffic patterns (and problems) of cities lying off the inter-urban thorough fares may well differ.

Transport Infrastructure, Service and Planning Problems. In more specific terms, in accordance with the settlement typology outlined earlier, Table 4.14 a-c indicates some of the most important transport deficiencies observed in the sample cities. The problem areas cited are categorised according to those associated with road infrastructure; transport services; and planning, management and maintenance tasks. Where these problems are common to other settlement typologies, this too has been shown. In addition to the preceding section, Appendix 2 gives a further account of transport performance problems of the same sample cities.

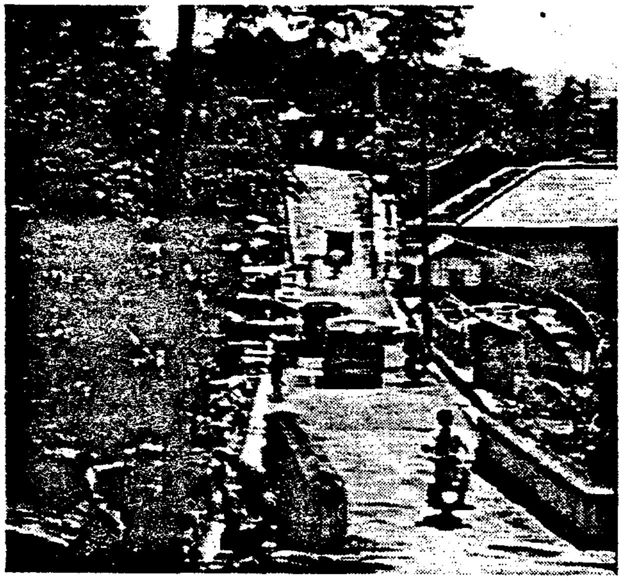


Figure 4.19: Minibuses providing peripheral public transport services in Magelang

In the smaller cities, such as Banjarnegara and Salatiga, the settlement-wide absence of adequate infrastructure to accommodate non-motorised travel is particularly problematic given the predominance of such movement. As regards public transport, the observed inadequacy of affordable services is believed to contribute to a greater reliance upon walking. This shortage of public transport services is in part a result of the high operational cost of transport arising from the poor conditions of local roads. With regard to the planning, management and maintenance of transport, the inadequate attention given to road maintenance and traffic enforcement is particularly problematic.

As in the case of many other intermediate cities in Indonesia, the most pressing transport infrastructure problem observed in Magelang is the urgent need for road widening to accommodate the rapid increase in through-traffic. Public transport services in the city were noted to be far too limited for a settlement of this size and pace of development. Problems of localised motorised traffic congestion were particularly observed around market areas and near major traffic generators, indicating the beginnings of larger problems to come unless transport planning and management measures are soon introduced.

One of the principal transport infrastructure problems observed in Solo and Bandung, was the inadequacy of non-motorised (especially pedestrian) facilities servicing those local inhabitants whose journey to work takes place in the same locality as their residence (see Figure 4.20). Also problematic is the fast rising demand on the periphery for new transport infrastructure.

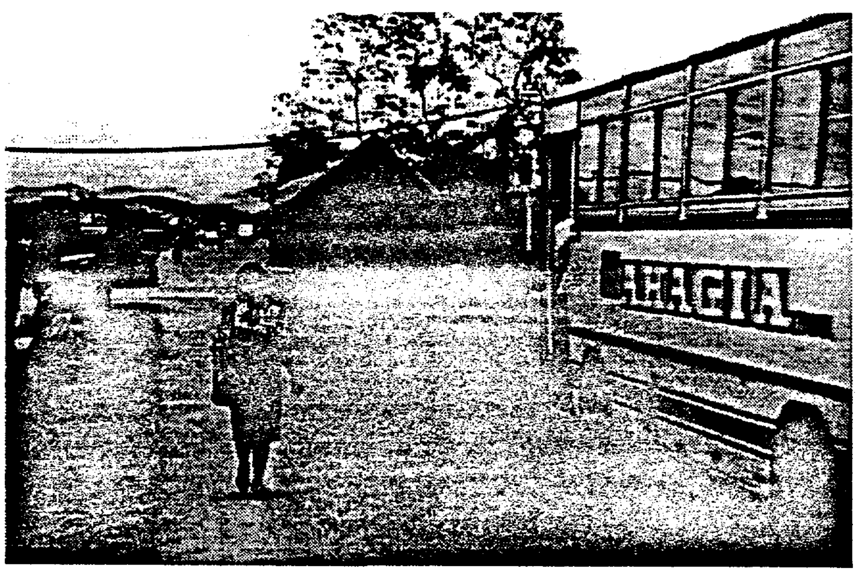


Figure 4.20: Roads without proper pedestrian facilities

Regarding public transport, and common to other large and metropolitan cities in Indonesia, Solo and Bandung experience major difficulties in accommodating the fast rising demand for bus services in the face of recent policy movements to reduce government subsidies to this area (see Chapter 3). This has led to an under-capitalisation, and the problematic financing of public sector operated buses, as well as declining quality of services. Also relating to the public transport field is the unresolved issue of how to plan for the *becak* and other traditional modes of transport (see Chapter 3). The urgent issue of how to respond to the additional land requirements needed to accommodate both increased on-street and off-street parking was noted to be a major difficulty for municipalities on the urban planning front.

Continuous Transport Networks

The conclusions to be drawn from the above, are firstly that travel demand at the 'urban village community' level in Javanese cities is strongly weighted in favour of short trips, thus making walking the most important means of travel (see Chapter 3 and Appendix 2); and secondly, that movement in the sample cities takes place in a physically restricted environment in which there is a strong correlation between trip distance and average speed, with higher speeds being preferred for longer trips.

The general implication of these and other observations regarding the appropriate use of urban transport modes and corresponding infrastructure, is that for the great proportion of homes access by four-wheeled motorised transport (particularly the motorcar) is not (and is unlikely to be) a realistic, affordable or desirable option for Indonesian cities. Furthermore, apart from walking, the use of compact and slow-moving modes is ideal for trips lower than the *Kecamatan* level, especially as feeders for motorised public transport in the case of higher community level trips.

This being the case, it has been suggested (TDC S.A., 1988) that city-wide and community-wide 'continuous transport networks' for pedestrians and compact/slower-moving transport modes should be provided to accommodate the greater part of short distance travel. This would overcome many of the observed traffic conflicts within Indonesian settlements, since it is apparent that such networks are absent not only in the settlements visited but in urban areas throughout the country.

It can be concluded from the above, that rather than a 'transport (mode) gap' of the kind identified by Bouladon (1967a and 1967b), the principal problem of cities in Indonesia is the presence of 'transport infrastructure gaps'. Furthermore, current transport planning and traffic enforcement practices in the country which discourage and neglect the required use of many paratransit modes such as the *becaks* (see Chapter 3) are ironically, slowly contributing toward the creation of a transport gap of the kind identified by Bouladon (1967a and 1967b).

With the above problems in mind, the provision of 'continuous transport networks' have the benefit of relieving the higher class roads of modal conflict and much unnecessary traffic congestion. Such networks could typically consist of the following (after TDC S.A., 1988):

- village footpaths and community roads with no motorised access or restricted access;
- local roads with a low volume of motorised traffic;
- sidewalks and/or non-motorised lanes along roads with a higher volume of motorised traffic;
- pedestrian and non-motorised crossings at roads with higher traffic volumes;
- pedestrian bridges or underpasses at roads with the highest traffic volumes.

The underlying principal of such a system is the provision of greater segregation of safe fast-moving motorised modes, slow-moving modes and pedestrian movement at all levels of the road hierarchy. This would favour fast-moving traffic at the higher levels of the road hierarchy and slow-moving traffic at the lower levels. To implement this successfully, however, priority for pedestrians at the lower levels needs to be incorporated into the infrastructure design, as well as the design and enforcement of traffic regulations.

The system in turn needs to be accompanied by a vibrant and aggressive educational publicity campaign designed to reverse current trends of transport mode and infrastructure misuse. While it has already been emphasised that a city's transport requirements are clearly a function of the interplay of a large number of factors outside the transport sector (see Chapter 3), the above findings also suggest that transport mode speed/distance relationships account for much of the observed traffic patterns generated in the sample cities.

Notes

(1) The latter part of this chapter (together with Appendices 1 and 2) is based on a study conducted by TDC S.A. on contract to UNDP/UNCHS and the Ministry of Public Works of the Government of Indonesia between 1987 and 1988 for which the author was the Project Director, Professor Budhy Soegijoko acted as consultant, and Sharif Horthy was the Project Manager.

(2) Noting this difficulty of measuring 'PCU' values in Third World countries, Cuthbert (1983) proposed a relationship for deriving the 'PCU' values of a vehicle called here 'P' in terms of its width in metres (W), its length in metres (L), the number of stops it makes in every 10 kilometres (s), its maximum speed in km/h (V) in relation to the free flow speed of the traffic on the road (V), and the effective road width in metres (E). The proposed relationship may be expressed as follows:

$$P = 15.8f + 0.2$$

$$f = \frac{WL(1 = 0.015s)}{E2(1 + 0.3V / V)}$$

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CURITIBA: TOWARDS SUSTAINABLE URBAN DEVELOPMENT

By Jonas Rabinovitch

Background

Curitiba is best known for its innovative public transport system based on buses but this is only one among many initiatives which have improved the environment and quality of life in the city, limited pollution and waste and reduced resource use. The public transport system has also been complemented by comprehensive initiatives in planning and land use management. This paper describes not only the development of the public transport system but also the planning and administrative framework that was needed to make it, and other initiatives taken in Curitiba, effective.

Curitiba is the capital of Parana, a mainly agricultural state in the south of Brazil. Located 900 metres above sea-level, near the coastal mountain ridge, the city dates from the seventeenth century and has long been an administrative and political centre. It developed rapidly as a city in the second half of the nineteenth century, underpinned by the arrival of many (mostly European) immigrants and the expansion of urban services and the opening of new economic frontiers; Curitiba had a central location on roads and railways and became a key service centre for new economic activities. It was designated the state capital in 1854.

However, until the second half of the twentieth century, physical, economic and demographic growth was relatively slow. There has been rapid economic and demographic growth in the last few decades which has transformed the city into an important industrial and commercial centre and a centre for transporting and processing agricultural goods. Today, the city has 1.6 million inhabitants and covers an area of 431 square kilometres; in 1965, it had less than 500,000 inhabitants. Service and commercial activities account for about 80 per cent of employment. Average per capita income is approximately US$ 2,5000 per annum.

Curitiba continues to be one of the fastest growing cities in Brazil. Despite this rapid growth, substantial improvements in the quality of life have been achieved - for example, the innovative public transport system, the preservation of the city's cultural heritage, the large expansion in the number and area of parks and green areas, the integration of social programmes and environmental education, the innovative " garbage that is not garbage" solid waste management system and the "garbage exchange" programme.

The Planning Process

During the Peak of Brazil's rapid urbanization in the 1960s, a decision was taken in Curitiba to concentrate on a planning frame work which emphasized the integration of all the elements within the urban system and which centred on a transport system that gave primacy to meeting the populations transport needs rather than primacy to those owning or using private automobiles. At this time, most Brazilian cities were being planned for cars and individual modes of transport. Initiatives undertaken by the local government in Curitiba allowed the city to plan, direct and control its growth process; it also avoided large-scale and expensive projects, but included hundreds of small modest initiatives.

In spatial terms, the key concept was to encourage Curitibas' physical expansion along linear axes which had at their centre a road with exclusive lane express bus ways. This sought to reduce the concentration of employment in Curitiba's traditional city centre areas and to return this central area to the pedestrian and permit the preservation of the city's cultural heritage. Through a coherent zoning programme, new developments in the central area were limited, and the commercial and service sectors expanded along structural axes towards north, south east and west.

The original plan for Curitiba came out of a public competition and the winning plan was made available to the municipal authority in 1965. In this same year, the municipal authority created the Curitiba Research and Urban Planning Institute (IPPUC) and this was allotted the following functions; to develop the master plan, develop studies and projects for the integrated development planning of the Curitiba metropolitan region, create conditions for the implementation, continuity and flexibility of proposals and coordinate local planning with policies at a regional, state and national level.

During the 1970s, three important elements influenced Curitiba's development: the rationalization of the integrated transport system, the development of the road network system, and land use legislation which allowed environmental preservation, cultural services and the meeting of human needs. These initiatives were later complemented by the development of the industrial city (a specially designated industrial area to the west of the city), which at present generates one fifth of all jobs in the metropolitan area without resulting in significant environmental problems, such as industrial pollution. What makes Curitiba unusual is not much having a coherent plan but the fact that is was implemented and that this plan was integrated with an effective public transport system and with various other initiatives to improve the quality of life in the city.

BOX 1: The Evolution of Curitiba's Public Transport System

1974: Implementation of the first two express bus lanes along the structural axes to the north and south

1978: Three new express busways added along structural axes

1978: Introduction of a new computerized area traffic control system

1979: Introduction of the social fare: a standard fare paid by all bus users which meant major benefits for bus users who lived on the city periphery (predominantly poorer groups) as shorter journeys subsidize longer ones

1979: Introduction of inter-district bus lines to complement the existing public transport system

1982: Opening of a new connection between the city centre and the industrial city and improvement of the inter-district routes

1991: Introduction of the Rapid Bus System (direct Lines) using boarding tubes

1992: Implementation of "Bi-Articulated Buses"

The Bus-centered Transport System

Curitiba's Public Transport system has developed over some 20 years; Box 1 outlines the main changes and modifications made over this period. During the 1970s, the city authorities began the implementation of an urban design structure which emphasized linear growth along structural axes. It also implemented the land use legislation that was required to make this effective. Curitiba planned road network and public transport system are probably the most influential elements accounting for the present shape of the city.

Over the years, urban growth has been encouraged along five main axes with 'structural" roads (see Map 1)/ Each axis is designed as a "trinary" road system. The central road has two exclusive bus lanes in the centre for express buses flanked by two local roads. Each side of this central road, one block away, are high capacity free-flowing one way roads, one for traffic flowing into the city, the other for traffic flowing out of the city. In the area adjacent to each axis, the land use legislation has encouraged high density occupation, together with services and commerce.

The whole of Curitiba is zoned according to the kind of use to which the land can be put and the density of development permitted, although mixed land uses are allowed. On the land sites located along the structural axes, this legislation permits buildings to have a total floor area of up to six times the plot size. Developments close to other kinds of road well served by public transport are also permitted relatively high coefficients-with floor space up to four times the plot size. This coefficient decreases the further a land site is from public transport. This has encouraged new commercial developments outside the central city, along each structural axis, and also high density residential developments so there is a match between high density residential and commercial areas and the availability of public transport. This has taken the commercial pressure off the central city which has permitted the central city areas to be returned to the pedestrians. One important complementary activity to the road system was the municipal government's acquisition of land along or close to the new transport axes, prior to their construction. This permitted the government to organize high density housing programmes close to the transport axes; in all, some 17,000 lower income families were located close to these.

Another important element of Curitiba's road network is the hierarchy of roads. Each road is assigned a function in relation to its location and importance. There are the "structural" roads along the five axes described above and "priority" links which connect traffic to the structural roads. "Collector" streets have commercial activity along them with all forms of traffic, and the "connector" streets linking the structural roads to the industrial city. These four types of road form the skeleton structure of Curitiba.

Despite having 500,000 cars (second highest car/capita ratio in Brazil). Curitiba does not have a traffic problem. When the present transportation system was initiated in 1974 under the first term of Mayor Jaime Lerner, the city decided to continued to restrict the city-wide transport system to the bus. The use of "express buses" on exclusive bus ways is far cheaper than subways or light railways and represents a more practical an affordable solution to public transport for a third World medium sized city

BOX 2: The Relative Costs of Different Public Transport Options

Public transport Option	Capital cost per kilometre
Underground metro System	$90-100 million
Light railway system	$20 million
Curitiba's direct route busway system (using boarding tubes)	$0.2 million

Along the main axes of the city, a central lane was set aside for buses only. New bus lines were created and expanded as the city grew. Map 1 shows how a series of circular inter-district bus routes developed, to complement the express busways. For the first time, a new mass transportation idea was created to meet the needs of a Brazilian city where the bus routes and land use were more important than the vehicle itself. Buses are calour coded: the express buses are red, inter-district buses are green and the conventional (feeder) buses are yellow.

One of the key concepts in the transportation system is the ease with which people can transfer from local buses to the express buses and back to other local buses. There is full integration between express buses, inter-district buses and conventional (feeder) buses. There are large bus terminals at the end of each of the five express busways where people can transfer to inter-district of feeder buses. One single fare is valid for all buses. Along each express route, smaller buses terminals are located approximately every 1,400 metres and are equipped with newspaper stands, public telephones, post office and small commercial facilities. Here passengers arrive on feeder buses and transfer to the express buses or inter-district buses.

One of the latest innovations is the introduction of the "direct" express bus system, where there are fewer stops and where passengers pay before boarding the buses in special raised tubular stations. These run along the one-way routes which run each side of the structural axes' central road. These new stations with platforms at the same height as the bus floors cut boarding and deboarding times; a rapid bus system with these 'boarding tubes' can take twice as many passengers per hour. They also take three times as many passengers per hour when compared to a conventional bus operating in a normal street. The boarding tubes also eliminate the need for a crew on the bus to collect fares, which frees up space for more passengers. In this way, one of Curitiba's express buses does the work of many traditional ones.

Curitiba's public transportation system is used by more than 1.3 million passengers each day, and attracts nearly two-thirds of the population. Twenty eight per cent of direct route bus users previously travelled in their cars. This has helped secure savings of up to 25 percent of fuel consumption city-wide. Curitiba's public transportation system is directly responsible for the city having one of the lowest rates of ambient air pollution in Brazil. Another effect of

Curitiba's transport policy is the savings for inhabitants in expenditure on transport; on average, residents spend only about 10 per cent of their income on transport which is a relatively low proportion for Brazil.

The mass transportation system implemented in 1974 is managed by URBS (Urbanization of Curitiba, a mixed capital company) and is continuously being developed by the Curitiba Research and Urban Planning Institute and by URBS. Since 1979, the introduction of inter-district lines, a standard fare for the whole network and new integrated terminals have allowed for the operation of a 514 kilometre network. Automatic fare collection, articulated buses and traffic lights which give priority to buses (operated by the vehicles themselves) allow the optimization of the system's operation and the low operating costs. New initiatives are constantly being sought to improve the system. For instance, a "bi-articulated" was implemented with a capacity of 270 passengers. These have five lateral doors for passenger entry or exit and significantly decrease boarding and deboarding times, when linked to the new boarding tubes. The vehicles were developed in Curitiba and some 33 of these should are operational from October 1992.

The buses operating within this integrated transport system are privately owned by companies which receive a concession from the municipal government to operate specific routes. These companies have to abide by the city government guidelines and monitoring policies. The bus companies are paid according to the number of kilometres their buses cover. Each bus company purchased a concession to operate particular routes with operational details and timetable defined by the municipal authorities. The whole public transport system operates with no direct financial subsidy.

The Industrial City

The Region's Economic structure began to change with the operation of an industrial city in 1973. Located seven miles from the city centre, it is well integrated within the urban structure and is equipped with services, infrastructure, schools, housing, green spaces and transportation axes connecting it to the rest of the city. One reason why the city authorities have been able to develop this industrial city without a high cost is that they own the entire site. Part of the site was already in public ownership when it began to be developed in 1973 while the rest was expropriated before the infrastructure was installed (and thus before the value of the land increased). Part of the land has been allocated to low-income public housing. With over 400 non-polluting industries, this industrial area now accounts for one-fifth of all jobs in the metropolitan area. Any industry wishing to locate in this industrial city must conform to local environmental legislation. Industries located within the metropolitan region of Curitiba account for 31 per cent of the industry in the state of Parana and generate over US$ 100 million annually.

Preserving Architectural Heritage, the Expansion of Parks and the Protection of Green

The integrated land use planning and transportation system has also permitted an enormous expansion in parks and green areas and the preservation of the architectural and cultural heritage in the city centre. The city centre underwent a major refurbishment process in the 1970s. Many streets became pedestrian areas while old buildings and the historic centre were protected, public squares upgraded and shopping and commercial facilities developed.

The municipal authorities encouraged the conversion of old building into new uses. Owners of buildings designated as of historic value are permitted to develop new uses in their buildings, but not to fundamentally change the facade and layout. In addition, to compensate for this restriction, the municipal authorities allow the owners to sell the development potential foregone to a builder for use on another site. One of the city's most popular shopping malls developed in what was previously a foundry. A former gun powder arsenal has been converted into a theatre and an old glue factory into a creativity centre. What had previously been the army headquarters has been converted into a cultural foundation and the city's oldest remaining house has become a documentation and publication centre. The old railway station has become a railway museum whilst a stone quarry has been converted into an open air theatre. In 1991, a "twenty-four hour street" was created downtown with the city authorities working in partnership with local merchants. Businesses here stay open 24 hours a day, seven days a week and this street has helped to sustain commercial activities in the city centre.

The city has a well defined policy and strong commitment towards preserving its woods and parks. In the past 20 years, more than 1.5 million trees have been planted in the city. The ratio of open space to inhabitant has increased from 0.5 square metres to 52 square metres which means that Curitiba has one of the highest averages of green space per inhabitant among urban areas worldwide. The Guarda Verde (the "green guard" - a municipal corporation) protects and maintains the green areas; the guards also keep the public informed about environmental issues and are trained for first aid.

There are also programmes to encourage community responsibility for care and maintenance of the parks - for instance the Association of Friends of the Park formed by volunteers, the Boy Scout Bicycle Watch to promote knowledge about them and about ecological principles. Another innovative feature of Curitiba's green spaces is their integration with flood control. The parks not only provide recreational and aesthetic value but many have artificial lakes which provide flood control for the entire city. Each park is equipped with information centres on the local environment and ecology. A 90-mile (145 kilometre) bike path mostly through the urban parks is nearly complete.

A recent addition is the new botanic gardens. This covers an area of 17.7 hectares and has been developed over an abandoned garbage dump. It includes some of the last remaining natural fauna and flora of the region. A museum is to be included along with a research facility to study local flora and the cultivation of native and exotic species, including species from lower coastal areas and other regions of the country. The city also provides a free bus service during the weekends on its "pro-park" line. These are "retired" city buses painted green which carry people from downtown to the city's numerous parks (Brazilian legislation demands that all buses in use the roads be less than ten years old.)

Social Services and Environmental Education

Like most cities, Curitiba strives to provide the social services needed by the inhabitants in the form of health care, child day care, adult education, rehabilitation programmes and others. To help provide more day care centres, the city is offering incentives to the private sector to supply more facilities. As part of the education system, the city has developed "mobile classrooms", which are remodelled old city buses. They run short courses for adults in the low-income sectors, sewing, carpentry and word-processing. These buses go to different low-income neighbourhoods each day of the week.

The city's recycling programme not only benefits the environment but helps those in most need. Money earned by the city from selling recyclable garbage is reinvested in the city's social programmes. A lack of education is one key reason for environmental destruction. By providing environmental education, the city hopes to improve the quality of life of low-income households, especially the children, and also to teach them to be responsible for their actions. In the case of the favela communities, a "self-subsistence education" is required which will teach them to respect and care for the environment they live in and from which they may benefit. One of the programmes addressing this need is the Infant and Adolescent Environmental Education Programme.

BOX 3: Integrating Environmental Education and Social Provision

Provision - the infant and Adolescent Environmental Education Programme (PIA)

This programme was created to educate children from the favelas and other low-income areas. Units set up for the programme are generally simply built rooms with wood - burning stoves for cooking and heating. These units offer a place for children to go to during the day. They are given a meal with the food usually prepared by volunteer mothers. For every 300 children there are two employees, making this programme very inexpensive and viable to run. Prior to PIA, no infrastructure existed to support any kind of day care. Most children wandered around their settlement unsupervised while their parents were away at work.

With the implementation of PIA, the children have a place which provided them with meals and practical education. Initially, there was some vandalism, but with patience from staff and educators, and without police intervention, adolescents to become involved in the programme. Among other things, PIA children are taught how to take care of younger children and how to clean and grow vegetables plus others skills which they can use elsewhere.

With ever increasing numbers, the programme has been growing to keep up with demand. Many teenagers are learning gardening skills and money earned as gardeners is passed on to their favela neighbourhood association. Before PIA, favela children were often isolated socially. Now they feel more part of a community and participate in cleaning, washing-up and cooking. The community is very satisfied with the results of the programme and gives its full support. Family life has improved and the surrounding environment is being protected and improved instead of being destroyed. This programme has been nominated as an United Nations Local Government Honours Programme by the International Council for Local Environmental Initiatives for "environmental regeneration of low-income communities". There are presently 25 operating PIA units. Each PIA unit looks after an average of 250 children

In addition to launching environmental education programmes in low-income districts, the city has incorporated environmental education into its education system, especially in the elementary schools. When Curitiba launched its recycling programme, city planners believed that the most effective way to teach people about the benefits or recycling was through the children. Much of the environmental education was taught by the "leaf" family, actors dressed up as leaves who visited schools, distributing brochures and who also appeared on television. The children responded positively to the idea of recycling (for instance collecting spent batteries and empty tooth paste tubes from their homes) and went home to teach their parents.

Another important education tool was the recent launching of the free Open University for the Environment. This provides courses for people from all backgrounds (for instance taxi drivers, journalists, child carers) to encourage awareness of the environment and the importance of its preservation. It is also involved in research and in developing local environmental project and is creating data library.

Conclusions

The experience of Curitiba demonstrates some principles which might be considered applicable elsewhere:

- An urban growth pattern should be established in conjunction with a conscious decision to promote an integration of different elements of urban development. A city must know where it is growing, how and why. Conscious technical, political and economic decisions should be made in response to existing trends. Many urban related problems linked to the uncontrolled physical expansion of cities (for instance increasing infrastructure and service costs, loss of agricultural land, minimum provision for open space) can be avoided if correct decisions are made at the right time.

- One of the key lessons from Curitiba's experience is the importance of establishing a close relationship between the public transport system, the land use legislation and the hierarchy of the urban road network. This can provide an integrated framework that can be used as a guidance and development tool.

- Successful decisions are also related to conscious technological choices and in many instance, the most appropriate choice may represent a challenge to certain technological dogmas. Curitiba has shown that a city with more than 1 million inhabitants does not necessarily need a "metro" style underground transport system or a light rail system and that surface solutions based on bused could be developed incrementally at a much lower cost. The city's solid waste programme has also shown that the recovery from household wastes of recyclable elements does not need an expensive mechanical separation plant, if a city transforms every household into a pre-separation plant with curbside collection schemes.

- Cities should pay attention to their visible structure (transport, housing, land use, etc.) as well as to their "hidden structure". City governments should understand the main economic opportunities and work towards developing them. The network of formal and informal economic relations should be supported and not hindered by urban planning actions.

- Total priority should be given to public transport rather than to private cars, and to pedestrians rather than to motorized vehicles. In Curitiba, less planning attention to meeting the needs of private motorized traffic has generated less use of private motorized traffic. Bicycle paths and pedestrian areas should be an integrated part of the road network and public transport system.

- A sustainable city is one that spends the minimum and spares the maximum. This choice relates to the pragmatic application of the principles of recycling. In the case of Curitiba this relates to solid waste, buses (mobile schools), houses (refurbishment) and people (low-income people being employed in the garbage separation plant and environmental education).

- The example of Curitiba seems to demonstrate that there is an "action script" for each set of problems. Solutions with any city are not specific and isolated but inter-connected. The "action script" should involve partnerships between responsible actors such as private sector entrepreneurs, non-governmental organizations, public organizations, mixed capital institutions, neighbourhood associations, community groups and individuals. This approach implies that the whole debate in favour or against privatization loses its importance when we accept the simple fact that there is a role for each actor within a given community and city and that these roles can be complementary.

- The role of every actor is a function of scale, means and knowledge. For instance, the city administration should be in a position to determine structural guidelines for the city and its wider region whereas citizens can better determine what is better for their own street or neighbourhood. A good balance between representation and participation is essential.

Creativity can substitute for financial resources. Ideally, cities should turn what are traditional sources of problems into resources. For instance, public transport, urban solid waste and unemployment are traditionally listed as problems but they have the potential to become generators of new resources and employment. Creative and labour intensive ideas could, to some extent, be substitutes for capital intensive technologies.A good information system is essential. The better the inhabitants know their city, the better they treat it. A team of officials should be developed locally who know the city well and who are committed to developing it.

LAND USE AND TRANSPORT RELATIONSHIPS: A PERSPECTIVE FROM THE UNITED STATES

By Samuel N. Seskin

Introduction

As transportation and land use planners and policy makers world wide grapple with the increasingly challenging consequences of automobile use, there is a growing need to communicate globally about both our knowledge of interactions between transport and land use and our ability to analyze these relationships in a systematic manner. As the world's largest consumer of energy in general and petroleum in particular, the United States continues to conduct research and innovate in integrated transportation and land use policy issues. The need for improving the state of knowledge and practice, however, is more compelling in developing nations, such as Chile and Thailand, from which, despite their transportation and environmental problems, the United States in fact has much to learn.

Nevertheless it is instructive to take a long and broad look at the way that we in the United States are planning and building our urban environments. This paper focuses on four aspects of that effort. The first is the state of our knowledge on the relationships between land use and travel demand. The second is the analytic tools we use to evaluate these relationships. Third is the array of approaches used by government to integrate transport and land use. The last is the ways in which individuals and organizations outside of the formal structure of government participate in metropolitan planning and development.

Linkages Between Land Use and Travel

Taking as a point of departure the work done by Pushkarev and Zupan (1977) and by Newman and Kenworthy (1989) on the relationships between density, automobile dependence and energy consumption, our U.S. planners affirm the dominant role of metropolitan area density in shaping the travel choices made by residents and workers. If one had to choose one indicator to guide policy makers in reducing automobile dependence, density would be that measure.

Nevertheless any rule has its exceptions and requires its qualifications. Regarding the dominant role of density in influencing travel behavior, it must be said that there are many parts of our country that are dense and yet hopelessly auto dependent. In fact, the Los Angeles, California metropolitan area, synonymous in most people's minds both here and abroad as being the epitome of an auto dependent metropolis, actually has the highest gross residential densities of any metropolitan area in the United States according to the 1990 Census. This fact alone is enough to make us reflect on the truth and usefulness of the axiom that density explains mode choice very well. Working with Jeffrey Zupan to update his 1977 work, I expect to be able to report within the next year on the current relationship between residential densities, employment center size and transit patronage in corridors across the United States.

Even as we work to update Public Transportation and Land Use Policy, we are also researching the ways in which land use at smaller geographic levels also influences travel behavior. There exists a substantial body of evidence that density exerts its strongest influence on travel behavior at the corridor level, rather than at the metropolitan level, which is why there are many corridors in which transit works well in the New York metropolitan area and few in greater Los Angeles, where densities are uniform rather than varied as is the case in greater New York.

In the United States, where auto ownership has exceeded all logical limits, vehicle trip generation rates per household and per capita as well as vehicle miles traveled per person or household continue to grow despite near ubiquitous auto ownership by people over the age of 16. In fact, the ratio of automobiles to driving age adults in even moderately affluent areas in the United States exceeds 1 to 1. Three car garages are now a standard feature of suburban houses in upper middle income neighborhoods. The growth in automobile use is fueled by both our strong affection for the technology and by a land use pattern which necessitates high levels of automobile ownership.

In order to evaluate the relationships between land use and transport, we need to examine each direction of the relationships separately. When we examine the ways in which land use influences travel demand, we must acknowledge the role of at least three different characteristics of the built environment. First is density. The total number of households per gross acre in residential neighborhoods in the United States is a significant indicator of a mode choice. Even in the City of Portland, Oregon, part of a metropolitan area of slightly more than one million people, the typical resident of a residential neighborhood close to the region's central business district will make more trips by non-motorized means than by mechanical modes. In Chicago, one of the largest cities in the United States, residents near the central business district are making in excess of 60% of their trips by non-motorized means. In Manhattan, the central borough of the City of New York, an even higher proportion of residents use non-motorized modes and only a small fraction of trips are made by automobile.

While we have portions of our great cities which do not depend on automobiles, much of the debate among policy makers is over how we can modify those portions which are already largely automobile dependent and make them less so. These are areas whose residential densities are often one-tenth those of cities in other developed nations which are considered transit friendly. In American terms they have a residential densities of fewer than five households per gross residential acre and typically fewer than three households per gross acre. Net residential densities in neighborhoods would be in the range of up to five units per acre. While many planners advocate changes in the design and diversity of such neighborhoods which would reduce auto dependence, it is clear that they will affect travel behavior only at the margins. Work in Portland suggests changes in vehicle trip generation rates of only a few percent in these essentially low density neighborhoods that could possibly result from introducing some non-residential uses and sidewalks, along with higher levels of transit service. The greater challenge is whether and how one can introduce neighborhoods of even moderate density (10 to 20 dwellings in a net residential acre) given the traditional resistance of existing residents to any change in their built environment of this kind.

These examples demonstrate, however, that it is important to look not only at gross household densities at the metropolitan level, but at densities at a finer geographic scale, if one wishes to understand travel behavior. This leads to a discussion of the second land use characteristic, the quality of the pedestrian environment.

Part of the research I have directed in Portland, Oregon, focuses on quantifying the ways in which the quality of the infrastructure used by pedestrians influences vehicle trip generation rates and automobile vehicle miles of travel. We defined the pedestrian environment in very simple terms. We asserted there were four factors which influenced automobile trip generation rates at the neighborhood level that have to do solely with the characteristics of the pedestrian environment. These are topographic conditions, connectivity of sidewalks, connectivity of streets and ease of street crossing at key intersections. We created a index which measured these four characteristics at the neighborhood (transportation zone) level. Using over 400 neighborhoods as a basis for this analysis, we demonstrated through the use of multiple regression techniques that these "pedestrian environmental factors" are statistically significant in influencing vehicle trip generation rates per person and per household and vehicle miles of travel and rates of automobile ownership.

The equations also contain various socioeconomic characteristics of the household (income, number of workers, number of automobiles owned) as well as various transportation characteristics (proximity to central business district, proximity to transit) and land use characteristic (gross zonal household densities). Thus we conclude there is something about the design of neighborhoods in the automobile age which accounts for travel behavior as well.

Third and last, it is axiomatic for American Planners to acknowledge the role of land use mix or diversity in influencing travel behavior. A small number of significant studies have been completed which indicate that the likelihood of making a non-work trip by means other than the automobile is explained in part by the richness and variety of the land uses in residential neighborhoods. In neighborhoods which are homogenous (exclusively residential in character) non-work trips are almost exclusively made by auto. In neighborhoods that have mixes of uses, a meaningful proportion of these trips are made by other modes (transit, bicycle or on foot). Research supporting these conclusions have been completed in Portland, (Oregon), Seattle, (Washington), San Francisco and elsewhere.

Research continues on ways in which neighborhood land use mix affects travel behavior. I am working with several other researchers on this question in the San Francisco region and the Chicago region. The results of other research is expected to be published soon. In summary, there are three characteristics of the built environment that influence mode choice and energy consumption. They are density, design and diversity. These complement one another and, when they do, they generate substantial synergies affecting travel behavior.

Looking at the other side of the relationship, the ways in which transportation influences land use, we must begin by acknowledging the dominant role of highways in inducing and directing growth, as a result both of their travel time advantages over all other modes and of the comfort and status associated with their use. Even as congestion reaches unparalleled levels in cities like Bangkok, affording the possibility that it may be just as fast to walk from one location to another as to take a car, the comfort and status associated with automobile use are difficult to deny.

At the same time we in the United States, with our relative abundance of highway infrastructure, can observe that the presence of highways is a necessary but not sufficient condition for urban development to occur. That is, there are more locations served by our expensive network of roads and highways than could possibly be developed. Thus, other factors clearly play a role in influencing the location and pace of urban development. We will come back to these factors in the next section of this paper.

Regarding the role of transit in influencing urban form, the consensus opinion among candid researchers in the United States is that transit in most American cities can support, but typically does not induce, in development. While transit supports more dense and extensive employment destinations, by virtue of its being able to bring a substantial number of people to these business districts who otherwise could not access them by car or any other means, the ability of transit alone to induce land use change proximate to station locations can be demonstrated only in a few of our largest cities. Both case study and statistical evidence suggest that there are stations on transit lines in our major metropolitan areas (Boston, New York, Philadelphia, Washington D.C., Chicago and elsewhere) where the presence of transit substantially enhances the attractiveness of built space by being able to bring workers to these locations who otherwise would find the cost of automobile parking prohibitively high. These are employment centers where upwards of 50% of employees are arriving by transit daily.

The limited, though notable locations where transit can be shown to influence employment center growth suggests an important lesson for developing cities. Where fixed guideway systems can delivery people more quickly, more economically and just as comfortably as can the automobile, there one can expect substantial development benefits to occur. In a city like Bangkok, the possibilities of reinforcing selected central employment locations with fixed rail transit service are notable. The benefits to employees, employers and members of society are substantial.

In summary, this quick review of the state of our knowledge about transport - land use and their relationships both confirms certain conclusions which are relevant to developing cities and also confirms a series of unique conditions which characterize the United States today. To the extent that suburbs of cities like Santiago begin to emulate these land use patterns, one can expect the same difficulties and challenges in reducing and reversing auto dependence that are evident in U.S. suburbs today.

Analytic Tools

There are a broad spectrum of analytic tools, methods and procedures which can be used to understand the ways in which transport and land use interact. Within the United States the following have and will continue to be used:

- Case studies and qualitative assessment methods
- Rule based quantitative assessment methods
- Sketch plan land use models
- Regional economic models
- "Traditional" four step travel demand models
- Linked transportation and land use models

Each has its advantages, depending in part on the nature of available data, budgetary resources and planning and policy goals and objectives that lead one to want to examine the relationships between transportation and land use. Qualitative assessment methods include the use of case studies for structured interviewing methods such as the "Delphi Method". The expert judgment of knowledgeable individuals can be employed quite successfully in evaluating the ways in which that transportation investment might effect land use. The "Delphi Process", was first described and evaluated in the U.S. in the early 1980's for land use planning purposes. It involves asking a cross-section of experts a series of structured questions, after by giving them a variety of background data on transportation and land use conditions in a corridor or study area. The responding experts write down their replies. Staff review and collate these responses and circulate them back (in anonymous fashion) to the respondents who have an opportunity to modify their first responses in light of the perspectives gained by reading the thoughts of other experts beside themselves. Staff then compile these second set of responses and, if the opinions of the respondents have begun to converge, summarize them in a report which represents the results of the assessment.

Less structured forms of qualitative assessment include straightforward case study techniques and accompanying descriptive statistics. In a world increasingly attracted to highly quantitative methods for evaluating social science problems, this approach may seem regressive. Nevertheless it can be quite effective and useful in helping planners understand transportation land use relationships in conjunction with the decision to build or modify a transportation system in a given region or corridor.

In a similar fashion, rule based quantitative assessment methods can be extremely useful. These result from the application of multiple-regression analysis and other models which derive elasticity estimates for specific variables such as the effect of increases in transit fare or land costs, etc. There are numerous applications of these kinds to transport-land use relationships.

There are at least half a dozen "sketch plan models" are available while help to evaluate the ways in which corridor level transportation investments, or different mixes of system wide regional transportation investments will effect the distribution of households and jobs. These models are essentially all derivatives of the Lowry Gravity Model. They typically operate with several dozen or as many as 100 zones and have relatively straight forward linear relationships which build on past trends in employment and household allocation to forecast future growth in response to changing travel impedance in each transportation analysis zone. These models are fairly inexpensive to obtain and, when they are used in regions where existing travel demand models already exist, with historic data bases of population, employment and travel behavior, can be calibrated fairly easily. They have a number of advantages over other, less quantitative tools. Their principle advantage is simply that qualitative and rule based methods tend to fall apart when dealing with a larger scale or metropolitan wide analysis of transportation and land use relationships. Even a simple sketch plan land use forecasting tool is better than no tool in trying to assess the ways in which transportation investments will influence metropolitan form.

Regional economic models have been used to understand the ways in which changes in travel times within a region can affect the rates and location of growth. They are at best imperfect substitutes for the use of the kinds of econometric land use model systems like MEPLAN. They do model the ways in which changes in travel time affects the productivity of businesses which, in turn may grow, employ new people, support new residential growth and thus alter urban form. In the context of this paper it is not possible to evaluate these in careful detail. Many of the applications of economic models are in intercity transportation investments rather than metropolitan investment studies. However, the state of the practice in this area in the United States is steadily changing.

Traditional four step travel demand forecasts can be used to understand the ways in which a different assignment of households in population may affect travel behavior (trip distribution, mode choice and trip assignment). They are by definition static models. They do not allow for any interaction between transportation and land use. They do allow the evaluation of various end states. Metropolitan planning organizations around the United States commonly employ these models to simulate the ways in which one or another pattern of urban form (distribution of location of households and jobs) might lead to various changes in travel behavior.

Lastly, we use a number of linked transportation and land use models. The state of the practice in integrated transportation and land use modeling in the United States as of several years ago is summarized in one volume of the work I have directed for 1000 Friends of Oregon. A more recent review of the state of the practice is found in the journal of the American Planning Association (Wagoner, 1994). The state of our work can be summarized in several points.

First, there exists in a number of larger metropolitan areas customized land use models. These metropolitan areas include Chicago, New York, San Francisco and elsewhere. These are at best, imperfectly integrated with existing regional travel and forecasting models. They represent a substantial advance in forecasts of future allocations of household and employment over other techniques, given the size of the metropolitan areas involved and their extraordinary complexity. In none of these jurisdictions, however, is the model easily integrated into the travel and forecasting process.

In a small number of jurisdictions including Seattle, Washington, and Portland, Oregon, there are linked transportation and land use model systems which allow for the full interaction between travel conditions and land use (household and employment allocation). Other jurisdictions, including Los Angeles, are working towards this end.

Lastly there are several dozen metropolitan planning organizations which make use of a single, proprietary commercial product called DRAM/EMPAL this model system, which is implicitly endorsed by at least one federal agency for use in transportation/environmental planning, is acknowledged to have a number of structural flaws which limit the confidence one may have in the results of its forecasts. These flaws include:

- The assumption of one worker per household
- The assumption of one job per worker
- The assumption that work place and residence are decision making is sequentially determined
- The absence of any information on land prices
- The absence of any mechanisms for dealing with land use and housing policy explicitly, forcing the user to override the model predictions
- The absence of any economic or econometric model which deals with supply and demand for space by different industries over time

All of these limitations are well documented in a number of places, including the report of the international study group on land use and transportation interactions (ISGLUTI). The paper prepared for this conference by Zegras, Guruswamy and Miller describes many of these points in more detail. In summary, a wide variety of analytic tools are being used in the United States to understand transportation/land use relationships. Each of them have their strengths and weaknesses, limitations and advantages.

Whether working in the United States or in any other country, it is fair to say that the tools used to analyze these relationships need to fit well into existing data, technologies and institutional constraints. For example, in extremely dynamic markets and metropolitan areas such as Bangkok and Santiago, planners ought to use caution and creativity in the use of integrated models for policy analysis because the available data may be too quickly obsolete. In Portland, where I have spent nearly three years trying to experiment with integrated transportation and land use models, I am acutely aware that technical and institutional problems themselves are sufficient to prolong the development of analytic tools beyond the point where they can be useful. When one adds in the additional challenge of getting up-to-date data on land supply, land rent, employment and household location and other factors known to affect the evolution of urban form, the use of integrated model systems becomes extremely problematic.

I am not suggesting that the use of such models is without merit. Nor am I suggesting that the technical and statistical problems frequently encountered in their use are insurmountable. Rather I suggest that all of us interested in transportation and land use both in the United States and around the work continue to innovate in integrated model system development out the same time that we acknowledge that other tools may be needed in the interim and that many of these tools already exist, perhaps neglected only because their limitations are more transparent. I think progress needs to be made on many fronts simultaneously in order for us to integrate us the practice of transportation and land use planning. I hope this conference furthers that goal.

Policy Tools

We can describe the variety of policy tools used in the United States to influence transportation/land use relationships as falling either into the area of institutions, regulations or expenditures. Institutionally, the leading edge of practice of public land use planning policy is to create metropolitan organizations that are effective in both analyzing future trends, developing consensus about transportation and land use plans and, in the best of circumstances, having the power to implement those plans. While metropolitan governments are scarce in the United States, they are dominant in developing nations.

Thus, the United States has much to learn from other countries about techniques for effective metropolitan coordination and governance. Portland, Oregon, has one of the most highly regarded metropolitan planning organizations in the United States. It has the policy through a recently adopted charter (approved by the voters) to establish a framework plan which binds all local governments in the metropolitan area to implement a certain land use plan. The final form of that plan is expected to be adopted the Fall of 1994. The planning organization, like other metropolitan planning organizations in the United States, has responsibility for coordinating the development of regional transport investments in all models. While the transit agency is statutorily separate, the metropolitan government has the power to absorb it if it so desires and actively manage the public transportation system as well.

Nevertheless, cooperation is a hallmark of the Oregon development planning process. The State's reputation as an innovator in land use planning derives from its homogeneity and relative isolation and the civility of public policy discussion which for a long time has prevailed in the state. Under the leadership of a particularly charismatic governor, the State of Oregon adopted the nation's first statewide land use planning program. The legislature and the public have supported it because, they felt, it would preserve their quality of life which they perceive as distinctly different from that available in other parts of the United States. It is a combination of a forward looking, innovative, government and conservative preservation of the status quo that seems to have characterized many land use programs in the United States.

In the United States local governments use a wide variety of regulatory techniques to manage transportation and land use relationships. Those areas that have succeeded best at this are places where there are dynamic, profitable private sector investments going on in a growing metropolitan area. Where private sector economic activity is stagnant, whether through a cyclical recession or for other reasons, it is very difficult for the public and private to form an effective partnership. It appears that in both Santiago and in Bangkok there exists a dynamic private sector, increasing the opportunities for successful collaboration of the government. Among the tools used effectively by the government of the United States to manage transport/land use interactions are the following:

- Urban Growth Boundaries

The Oregon land use system established growth boundaries 20 years ago around all of its cities. These boundaries incorporate at least a 20 year supply of developable land, sufficient to insure the successful working of private land markets. They do in this way contain the growth of urban areas. Thus far, the policies have not affected the type of urbanization which has occurred. Much of the growth in the last 20 years has been automobile oriented.

- Adequate Public Facilities Ordinances

There are a wide variety of such ordinances in place. Conceptually they are intended to link the location and timing of development with the availability of public infrastructure, including transport, water and sewer, schools, recreation and other publicly supplied goods and services. Again, there are many success stories that demonstrate that this kind of process can minimize the adverse affects of rapid growth. Programs in Maryland, Florida, Colorado and elsewhere are evidence of this. None of these programs are designed to deal with automobile dependence and energy use, but they could be if transport planning were oriented toward the provision of those kinds of modal investments that reduce energy use per capita.

- Local General Plans

Also known as specific area plans or comprehensive plans, these are typically enacted at the municipal level, not the metropolitan level. They are the dominant form of land use planning framework used in the United States. They afford opportunities to specify the intensity, location, characteristics, design and amenities associated with land uses and developments within the area they encompass. Today, many jurisdictions are combining these with a set of urban design guidelines which require the provision of adequate pedestrian and bicycle amenities by the public and private sectors and attempt to create places which work for a variety of transportation modes other than the automobile.

- Land Owner Cartels

In certain rapidly growing areas, such as within the state of Florida, one or more landowners have developed plans together for urban developments and supporting services. These developments typically are located in areas that do not have much public infrastructure investment. The private sector, in combination with the public, often provides streets and highways, local transit systems or circulator systems, schools, dedicated open space and the like as part of the development process. The advantage of a small number of land owners working together is that the plans can often be forged in substantially less time than is required in areas where the land ownership is fragmented because of a lengthy history of settlement.

- Integrated Transportation and Land Use Planning

Portland is among the regions in the United States which is pioneering in the integration of transportation and land use planning. The transit agency, in conjunction with the construction of new light rail facilities, is working with local jurisdictions to ensure that local land use plans in station areas support the transit system through the location of transit supportive land uses and densities and the exclusion of auto dependent uses. The transit agency is providing substantial technical assistance.

Understandings between the transit agency and units of local government concerning the need for this kind of planning have been part of the transportation planning process from its inception. In a similar way, the metropolitan planning organization in Portland is developing a single, integrated transportation and land use plan for the region. Transportation and land use planning are not conducted by separate departments, authorities or organizations. The explicit integration of these two planning functions into a single agency and the management of these functions simultaneously represents the direction clearly needed not only in developing cities but in many cities of the United States as well.

There are at least two areas of the integration of transportation and land use planning which are not progressing particularly well, and in which innovations have produced only modest results. One is the use of higher fees, taxes and charges for automobiles. Federal agencies are aggressively pursuing opportunities to demonstrate the benefits of congestion pricing across the United States, but fewer than one dozen jurisdictions have taken serious interest in this opportunity despite generous financial inducements from the U.S. government. Nevertheless, there will be innovation of this kind within the next decade within the United States.

Lastly, the integration of jobs and housing in a manner that minimizes the long commutes which low income workers are obliged to make to reach their jobs has had very limited success in the United States. While the United States has made great progress in the integration of races, it has made little progress as a society in the integration of different economic classes. In those communities which are viewed as especially attractive places to live, the operation of the market has valued real estate sufficiently highly that people of modest means are typically unable to live in proximity to these desirable communities. Our efforts to overcome this problem have focused on the introduction of scattered, publicly assisted housing in relatively affluent jurisdictions and on the creation of "enterprise zones" which are designed to provide substantial financial inducements to the creation of employment opportunities in economically disadvantaged neighborhoods. While there are examples of success in both these areas, substantial work remains to be done.

The Role of Non-Governmental Organizations

The practice of public policy in the United States has always been characterized by a spirit of innovation and creativity. This is a result of both dedicated public servants and of the characteristics of American culture which are oriented toward solving problems and are suppose to believe that solutions to all problems are within reach.

The spirit of optimism also accounts for the relatively high level of public participation in the planning process which is typical in the United States. Well rooted democratic traditions and levels of economic prosperity have combined to afford citizens the opportunity and the time to take an active role in the governing of their communities. Public involvement in land use and transportation planning often, but not always, takes the form of resistance to change. As is best, however, public involvement often is responsible for change in government which otherwise would not occur.

1000 Friends of Oregon, a state wide land use advocacy organization, exemplifies the tradition of citizen activism. Since the creation of Oregon's land use planning system, 1000 Friends of Oregon has been an independent advocacy organization supported by its members, whose job it is to watch the implementation of land use plans. Their trained legal staff is not reluctant to litigate if they feel local government has violated state land use planning requirements. Their style of activism is characteristic of a number of environmental organizations in the United

States which have succeeded in dramatically influencing transportation and environmental policy over the last 20 years.

In the San Francisco area, a lawsuit by the local chapter of the Sierra Club resulted in a momentous decision which essentially invalidated the transportation planning in the metropolitan area because, the plaintiffs argued, they failed to consider the ways that continued emphasis on highway investments were causing adverse environmental consequences for the region as a whole. They argued that existing travel demand forecasting models failed to forecast these changes. The truth in their argument has lead to the recent wave of innovation in the implementation of integrated modeling in the United States today.

In Washington D.C., organizations like the Natural Resources Defense Council, the Surface Transportation Policy Project and a host of others are actively involved in lobbying the national legislature. They are willing to take the federal government to court when it fails to comply with congressional requirements. One should not underestimate the role of non-governmental organizations, most of whom are supported by a broad coalition of citizen activists (as well as a small number of influential donors and foundations). As standards of living rise for an increasing number of residents in developing nations around the world, it is fair to expect that citizen activists, individually and collectively, will play a greater role in influencing their government. This role will likely have both its conservative and radical qualities, as it has here in the United States. On the conservative side, residents will frequently oppose change, such as the construction of a highway or, in some cases even a new fixed rail system with stations proximate to their homes.

At its most progressive, citizen organizations will oblige their elected officials to innovate to enhance the quality of their lives through improvements to air quality, as these begin to be perceived as not only nuisances but as sources of substantial risk to their health. However these individuals and organizations manifest themselves in various cultures around the world, they do exemplify an important means by which transportation, land use and environmental quality may be enhanced for the benefit of present and future generations.

Summary and Conclusions

In the dynamic and rapidly changing environments of cities in developing nations, planners and officials look to the United States for ideas and evidence as well as for technology which may be used to solve globally pressing problems. In the area in transport-land use and the environment, the United States clearly furnishes such examples. We can all look forward to a growing level of communication and growing cooperation in the solution of problems of mutual interest.

Workshop Observations, Conclusions, and Recommendations for Moving Forward

Results of the Small Group Discussions

Observations

Bangkok currently has enormous numbers of motorised vehicles. The number of motor vehicles registered in Bangkok in 1993 was about 2.6 million of which over 1 million were cars and around 1.1 million were motorcycles. The vehicle population is noticeably increasing at about 12% over the previous year, despite the traffic congestion which is nearly at gridlock. Overall average traffic speed in the Bangkok metropolitan area is around 10 km/h. However, during peak hours on some main roads in the central business area, the crawl rate is at 1-2 km/h, or only half walking pace.

There are number of reasons for the rapid growth in motor vehicles which is disproportionate to income levels compared to other Asian cities such as Singapore. These include low import tariffs on motor vehicles and active encouragement of the car industry in Thailand, as well as the lack of a good public transport system and poor conditions for walking and cycling.

There are, however, several circumstances to be addressed before Bangkok can begin to overcome its air quality and congestion problems. The first is that many of the city's transport planners that design transport projects, and the policymakers with investment authority appear to be caught in the same conventional transport planning paradigm as many other industrializing and industrialized countries. That paradigm, pioneered in the United States and exported to much of the world, defines the problems as a shortage of road space to meet demand for, private, vehicular mobility. The investment focus is almost exclusively on the construction of large road-based infrastructure to machines instead of people while de-emphasizing other forms of transport such as rail, water, and non-motorized transport -- even if they are a less expensive investment that can meet demand.

The predominance of this paradigm results in a persistent myth held by many of Bangkok's policymakers, transport and urban planners, financiers, and citizens. The myth is that the city does not have enough kilometers of roadways per person, and should focus on road and highway investment in order to solve their air quality and congestion problems. In Bangkok, there are approximately 0.6 metres of road length per person, and 11 percent of the land in Bangkok is consumed by roadspace. In comparison, other cities similar in size have much greater length of road per person, and as high as 30 percent of urbanised land devoted to roads. The result is an attempt by the majority of transport Thai planners to raise per capita road space, and the amount of urban land devoted to it.

Conclusions

The problem is that it is not socially, physically or financially feasible the attempt to raise road space in Bangkok. Even if the total amount of urban land devoted to roads reach 20 percent, the number of people that would be displaced is estimated to be the equivalent of the population of Chiang Mai -- the second largest city in Thailand -- not to mention a large number of jobs. Thus the basic problem in Bangkok is not a lack of road space, but a poorly managed and developed transport system overall, with insufficient investment in mass transit system, and little to no integration between land use and transport system development.

The price of the conventional transport planning paradigm and its exclusive focus on road and highway investment is that Bangkokians are presented with limited options from which to choose to meet their daily travel needs. In the meantime, as a variety of mass transit projects and measures to reduce travel demand are proposed, but then not implemented. The result is that the city's air quality deteriorates and traffic congestion increases affecting the quality of life of millions of people every day.

A major barrier blocking the implementation of transport improvement projects are conflicts and overlapping areas of authority between projects. For example, there is the conflict between the Don Muang Tollway and Hopewell Expressway. They are in close proximity (under 2 km.) to one another and are planned to be under construction at the same time. The difficulty is that the Don Muang Tollway contract has a condition to prohibit any competing project to be built within a distance of 2 km. -- creating conflict surrounding the planned Hopewell Expressway. While these issues are the outcome of a lack of Transport Master Plan, the true culprit is the lack of coordination between relevant government agencies and commitment on the part of policymakers to address the problem with a unified approach.

The Most Promising and Policy Alternatives Modal Options for Bangkok

Throughout the course of the Transport Growth in Bangkok: Energy, Environment, and Traffic Congestion workshop, a variety of transport system management and development/investment practices have been examined for their applicability in Bangkok. The conclusion is that instead of imitating the conventional transport planning paradigm, Bangkok should follow its own lead and create an urban environment and transport system based on the city's unique set of attributes. Attributes (common among many Asian cities) such as vibrant communities and lively street life; high density neighborhoods with highly integrated residential, business, and shopping areas; and a diversity of travel modes already in place including water transport are the city's greatest assets.

Bangkok's urban community and transport system assets should not be squandered on an ill-fitting paradigm of urban and transport system development -- especially since that paradigm is beginning to be seriously questioned on the basis of its ecological, financial, physical, and social viability. Consequently, a different transport planning paradigm is needed which is more suited to the concentrated urban form, high density and rich, street-based cultural traditions of Asian cities. To be appropriate and effective for Bangkok, such a paradigm should include (but not be limited to) the following policy stances, and an investment and implementation emphasis in the following modes of travel:

1. **Policy: Public Transport Investment and Implementation Priority.** In some automobile-based cities such as Portland and Los Angeles in the USA and in Asian cities such as Metro Manila, public transport (particularly urban trains) have been introduced to provide alternatives to cars. In Portland one freeway was knocked down and a public park was built in its place. Another planned freeway in Portland

(the Mt. Hood freeway) was scrapped and funds used to build a light rail line. Many cities are learning from their own experience that the road-based transport paradigm cannot solve all traffic problems. In fact, increasing evidence demonstrates that more roads actually attract more cars (in part due to latent demand) and encourages more trips (in part through increased sprawl).

Curitiba, a well-known Brazilian city, is another example of a city that has, in this case, successfully integrated land use with a revitalized bus system, while other cities in Brazil have taken a different path. The city shows how a good public transport system can contribute not only to efficient travel, but also to people's lives, including those with less opportunity such as people with disabilities and aged citizens.

2. **Policy: Integrate Land Use and Transport Impact Analysis and Investment.** In Bangkok there is a particular need to understand how to integrate new development with public transport and the potential to walk and cycle as was done successfully in Curitiba. Present patterns of new high density apartments and dispersed townhouse and condominium developments are all predicated on the use of cars. Cars feature strongly in the marketing of these new developments. There is little attempt being made to integrate development with public transport systems, especially rail. This is leading to intolerable new pressure on the road system of Bangkok. On the other hand, many parts of Bangkok already offer ideal transit environments because they are built linearly along corridors. All that is missing, besides the political will to effect change, is a high quality public transport system to support the travel demand.

3. **Policy: Institutional Reform.** To tackle Bangkok's traffic disaster the government, through a number of relevant agencies (around 20), has proposed many transportation

projects, e.g. expressways, urban trains, roads, traffic management schemes etc. During the 7th National Social and Economic Development Plan (1992-1996) such projects require a 335 billion baht budget or about 12% of the total national budget. Yet it is estimated that there will be an annual shortfall of 15-20 billion baht if all projects are to be invested.

From the OCMRT report it is likely to be an auspicious start that the transport investment during the 5 years of the 7th plan has been said to shift from the investment in roads and expressways to investment in public transport. Nevertheless, the investment in expressways and roads still accounts for nearly two-thirds of the total transport investment, while public transport investment accounts for only one-third. The Traffic and Transport Master plan for Bangkok and OCMRT action plans are still based on traditional transportation policy and planning which emphasizes the improvement of infrastructure, particularly roads and expressways to ease traffic congestion.

4. **Policy: Balancing Environmental Considerations.** Even though the urban train mega-projects are also proposed, they have been impeded by a number of conflicts between different interest groups and seem unlikely to occur in the near future. Further delays are likely as these train projects are being subjected to what might be considered excessive environmental impact procedures, given their potential to begin solving some of Bangkok's already extreme road-based environmental problems. Whilst it is important that all major projects be subjected to environmental considerations, a sense of perspective needs to be maintained.

For example, the visual intrusion of the comparatively modest structure required for an elevated train, needs to be seen in context with the already extreme intrusion of existing and proposed elevated freeway structures which seem to have passed the environmental requirements. Mass transit's potential to improve Bangkok's already seriously deteriorated environment needs to be weighed up against any relatively minor environmental impacts which the mass transit system itself may introduce.

5. **Investment in Modal Diversity: Waterway Transportation.** Bangkok is sitting on an alluvial plain with a comprehensive network of river and canals, waterway transportation (which used to be the most popular mode for travel), has been ignored in current transport plans, despite its high potential to effectively supplement for land transport. It is the most pleasant way to travel in Bangkok due to lower temperatures and the separation of the waterways from the noise and fumes of the road system. Bangkok still has a comprehensive network of river and canals, even though a number of them were filled in and were replaced by roads. Many canals still have potential to be developed into an attractive transport alternative for Bangkokians.

   The existing boat services along the river and a few canals have proved that they can provide faster, speedier service than road-based transportation and without the choking air pollution of the streets. To be more popular, however, the quality of boats and jetties need to be upgraded and a more reliable, comprehensive service introduced.

6. **Investment in Modal Diversity: Cycling and Walking.** Pedestrianisation and facilities for bikes also generate little interest in government plans. Consequently, the walking and cycling rate in Bangkok is very low, for the compact, dense, mixed use city Bangkok represents. Many Bangkokians make only very short trips (average trip length was only about 6.6 km in 1989 which means many trips are very much less than this and in the range of a foot or bicycle trip). Accommodating walking and cycling by

providing basic infrastructure is very cost-effective and can potentially attract people from motor vehicles.

The main barrier to walking and cycling in Bangkok is a lack of infrastructure. Most sois and roads have no footpaths and walking and cycling can be very dangerous due to the proximity of intense car and motorbike traffic. There is also no shade for people on foot or bike and the noise from traffic is severe, particularly from motor bikes. Coupled with severe air pollution, Bangkokians are reluctant to walk even for short distances. Walking and cycling in Bangkok share only 15% of all daily trips compared to 45% in Tokyo and over 50% in some European cities such as Erlangen in southern Germany and Groningen in The Netherlands.

From a regional perspective non-motorised transport, particularly bicycles and rickshaws, still play a very important role in moving people and goods in a number of cities in Asia e.g. Jakarta, Surabaya, Beijing, Calcutta, Delhi etc. In Surabaya for example, they constitute 53% of daily trips and in Jakarta 40%. These modes of transport cater for poorer people. They provide a very economical service and also create many local jobs, both directly in the transport service and in the manufacture, repairs and maintenance of the simple vehicles. In addition, non-motorised modes are environmentally friendly.

Yet, in some cities non-motorised modes are considered by short-sighted planners as barriers to traffic and in many cases are being eliminated (e.g. Jakarta's becaks). In some cases they are considered by politicians to be symbols of backwardness. Notwithstanding, in a number of richer, modern cities such as Tokyo, Amsterdam, Munich, Copenhegen etc., bicycling provides great benefits to city living and obtains high priority from government. Moreover, in some American cities which are basically car-based, more people are realizing the benefits of cycling and strong advocacy for this mode is evident now. There is also much greater recognition in both Europe and North America today about the value of creating environments which encourage and cater for walking.

Recommendations: Specific Actions to be Taken

The most debilitating barriers s that there are too many government agencies with overlapping authority for planning and investment decisions. Needed is some form of institutional change, and the concomitant political will to make change happen. Despite a coordinated government, however, any measure to try and reduce and manage travel demand is likely to provoke strong resistance from car users. This is an obvious obstacle to making and implementing decisions for any government.

Planners and policymakers in Bangkok must therefore seek to not only solicit input from the public, but also seek to better inform them of the various trade offs among investment options. There are several mechanisms to foster this process. One vary important aspect to realizing change is the involvement of the non-governmental organizations (NGOs). These types of organizations, be they environmental or citizens' groups, can be very effective in creating change if they successfully maintain their impartial stance as non-political and issue oriented, without a stake in the local power structure. As such they are well-positioned to promote and argue for change based on social and environmental need, and an objective rationale using well-researched and analyzed information.

Given the political and institutional nature of Bangkok's barriers to devising and implementing transport improvement projects, the workshop participants directed their recommendation to the local and international NGO community. The recommendations are as follows:

Immediate Actions

Local and international NGOs express the suggestions drawn from this workshop to as many relevant agencies as possible. Such agencies include government bodies (not only the OCMRT but all relevant agencies), other NGOs, the private sector, and the media. Regularly inform these bodies through relevant studies that indicate the new shift in transport planning and lessons from other cities. Provide up-to-date information on new and developing technologies, or innovative policies. Keep such groups informed of the transport lending policies that affect project financing and prioritization. Intensify the debate by including and helping (through training on effective public policy analysis and debate, and mechanism to transfer critical technical information) local environmental NGO's and citizens groups to lobby their policymakers immediately for:

1. Better traffic discipline through
   - driver training
   - traffic law enforcement
2. Moving people rather than vehicles
   - more bus priority
   - enforcement of existing lanes in major bus corridors
   - guided bus experiments
3. Using the existing street surface efficiently
   - computerized traffic control of junctions
   - new junction design and flyovers
4. Establish an integrated management institition

Longer-term Actions

Maintain effective communication constantly with these agencies to build relationships, and to transfer latest information back and forth. Conduct trainings on effective public policy analysis and debate concerning urban development and transport systems to local NGOs.

Without this element of effective lobbying by the NGOs, it is unlikely that the necessary momentum can be developed to put Bangkok on the path towards a more livable city. Most of the positive developments in other cities have some degree of active citizen lobbying and support. Unfortunately, there is hardly any public participation in the planning process in Thailand. In order to invoke public participation IIEC should:

- Contact more local (and international) NGOs and convince them to turn their interest toward urban community development and transport investment issues, particularly its impact on air quality -- and by association public health -- and traffic congestion. Very few Thai NGOs are paying any attention to transport issues.

- Organize or support workshops and training courses on public participation by cooperating with Thai and overseas institutes. The aim here would be to provide and exchange experiences with relevant NGOs (including educators, planners, press and other relevant people).

- Support NGOs and other relevant people in any attempts to inform, educate or assist local people about transportation issues and any attempts to invoke public participation - in other words, the IIEC could help to 'resource' people as much as possible to get active in the transportation debate. Support relevant studies which try to search for suitable solutions for Bangkok's traffic problems and assist in distributing them.