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Traffic Management in Motorcycle Dependent Cities

A dissertation submitted in fulfilment of the requirements for the Degree of Doktor-Ingenieur (Dr-Ing.) of the Department of Civil Engineering and Geodesy, Darmstadt University of Technology.

by

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I, Khuat Viet Hung, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

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Abstract

Many Asian cities, such as Hanoi, Bangkok, and Taipei, experience a special situation, the so-called motorcycle dependence. In these cities, urban transport system is dominated by the motorcycle. This domination influences urban form and land use pattern of the cities by remaining and growing of many two-wheeler accessed only blocks and motorcycle-based land uses. Nowadays, people in motorcycle dependent cities (MDCs) are quickly shifting to travelling by car instead of motorcycle.

Under the conditions of high-density urban area, lack of roads and parking facilities, poor public transport, and immaturity of society in motorisation of transport of MDCs, the transport problems, namely accident, congestion, and pollution, have become very different from and much severer than those in developed cities have. While MDCs are still poor and having competing needs in using their limited resources, they cannot dream have an ordinary automobile or transit oriented transport system as in developed cities.

In the vision to achieve a liveable city with a sustainable transport system, a traffic management concept is a critical means for MDCs' in dealing with transport problems in short terms, while infrastructure and heavy public transport are the long-term solutions. This concept starts with a Strategic Policy Framework, in which a hierarchy of vision, goals and objectives have been completely formulated.

The applicable measures are recommended by establishing and applying a multi-criteria assessment model, in which the effectiveness of the measure is assessed by the level of achievement of four strategic goals for a sustainable transport system: (i) to ensure urban mobility, (ii) to ensure urban traffic safety, (iii) to protect urban environment, and (iv) to improve urban and regional economy. Applicability of the measure is assessed indirectly by the level of difficulty in overcoming four basic barriers: (i) cost of measure, (ii) technical systems, (iii) institutional participation, and (iv) public acceptance.

After the assessment, thirty-four candidate measures are classified into four groups, in which the first priority group was recommended to apply generally in Motorcycle Dependent Cities. This group consists of fifteen highly effective and applicable traffic management measures in five modal categories. For public transport, five measures are recommended: (i) Routing Improvement, (ii) Scheduling improvement, (iii) Public Transport User Incentive, (iv) Public Transport Information Service, and (v) Public Transport Management Centre. Three Non-motorised transport measures are Sidewalks and Pedestrians Crossing Facilities, Non-motorised Transport Zone, Non-motorised Transport Information Service. Only two measures for individual motorised vehicles are Vehicle Taxes and Duties, and Vehicle Registration Control. For multimodal transport, four measures have been selected, including Signalisation of Intersection Control; Traffic Calming and Speed Reduction; Urban Traffic Information Service; Land Use Change. Finally, City Logistic Management System is the only freight transport improvement measures.

A two-steps strategy formulation model has been established to combine the applicable measures into strategies. Two crucial principles should be followed in integrating traffic management measures are (i) to achieve synergic effectiveness, and (ii) to reduce and eliminate barriers in implementation. Four major traffic management strategies have been formulated. **Traffic Avoiding Strategy** consists of two traffic management measures, *Land*

Use Change and *City Logistic*, which are defined as the Basic Measures of the strategy. **Traffic Shifting Strategy** includes ten Basic Measures, which are five public transport measures (*PT Routing, PT Scheduling, PT User Incentives, PT Information, Management Centre*), three NMT measures (*Pedestrian Facilities, NMT Zone, NMT Information*) and two IMV measures (*Taxes and Duties, Registration Control*). In assessing the capability of Supportive Measure, *Signalisation* is selected to provide all required intersection operation and control systems. **Traffic Controlling Strategy** includes desirably five Basic Measures, which are one non-motorised transport measure (*Pedestrian Facilities*), one measure for IMVs (*Registration Control*) and other three multimodal measures (*Signalisation, Traffic Calming, Traffic Information*). The **Integrated Traffic Management Strategy** includes seventeen traffic management measures. Fifteen Basic Measures are expected to influence urban transport system in all three areas: to avoid traffic, to shift traffic, and to control traffic. The inclusion of other two economic measures, *Road Pricing and Parking Pricing*, as financial Supportive Measures for the strategy was recommended.

Finally, a proposal for application of traffic management strategies and measures has been adopted for Hanoi, Vietnam. The urban transport conditions of Hanoi City are defined in four typical urban transport situations as follows: ***(i) Overall Conurbation, (ii) City Centre, (iii) Arterial,*** *and* ***(iv) Two-wheeler accessed only blocks***. In correspondence with these situations, applications of four typical traffic management strategies are examined as follows:

Traffic Avoiding Strategy is applicable to ***Overall Conurbation*** and the ***City Centre*** of Hanoi in a large scale and medium-term project. The smaller scale and short-term of this strategy can be applied effectively for the two-wheeler blocks.

Traffic Shifting Strategy can be applied for large urban areas, ***Conurbation*** and ***City Centre***, in which the later situations, ***Arterials*** and ***Two-Wheeler Block,*** are included.

Traffic Controlling Strategy can be applied in all four situations and it is the major traffic strategy to be recommended for ***Arterials*** and ***Two-Wheeler Block***.

Integrated Traffic Management Strategy is suitable to apply for ***Overall Conurbation*** of Hanoi. Reduced versions can be considered to apply to the ***City Centre***.

The proposal also includes discussions about application of the fist priority traffic management measures.

Regarding scale of application, seven measures are fully applicable to all transport modes under a general strategy. Eleven measures are fully applicable and other twos are partly applicable under a modal strategic approach. Ten measures can be applied to a facility or service unit of certain transport mode.

Regarding the area of application, except the *NMT Zone,* all measures are fully applicable to the ***Conurbation***. Twelve measures are fully applicable for the ***City Centre***, while only seven measures can be applied fully along the urban ***Arterials***, and six measures are fully applicable to the ***Two-Wheeler Block***.

For implementing these measures, Hanoi Department of Transport and Urban Works and Services and its subordinate bureaus are the key authorities for the planning, provision and operation of the measures.

For the enforcement and control of traffic signal system, Hanoi Traffic Police Bureau is the main responsible institution.

Regarding public transport, Hanoi Transport Corporation (TRANSERCO) is the most important operator in both passenger and freight transport.

The key political decision-makers in Hanoi are Hanoi People Committee and Hanoi People Council. However, the most powerful body is the City Communist Party Committee.

As the most important finding, The Traffic Management Concept, which included a Strategic Policy Framework (as the goals) and the traffic management strategies and measures (as the means) can be widely applied for the motorcycle dependent cities and other developing cities in Asia and other regions.

In addition, the Assessment Model for Measures and the Strategy Formulation Model are applicable and can be further developed to be comprehensive and quantitative model and sub-models.

Finally, the proposal for applications of Strategies and Measures in Hanoi should be further developed at the project level for implementation.

Kurzfassung

Viele asiatische Städte, z. B. Hanoi, Bangkok and Taipeh, befinden sich in einer besonderen Situation, der so genannten Motorrad-Abhängigkeit. In diesen Städten wird das städtische Verkehrssystem von Motorrädern dominiert. Diese Dominanz hat Auswirkungen die Stadtgestaltung und die Flächennutzung der Städte durch das Vorhandensein und die Ausweitung vieler nur für Zweiräder zugänglicher Viertel sowie durch auf die Motorradnutzung ausgerichtete Flächennutzungen. Derzeit steigt allerdings die Bedeutung des Pkw im Vergleich zu der des Motorrads bei Bewohnern in den vom Motorrad abhängigen Städten (engl.: Motorcycle Dependent Cities – MDCs).

Unter der Bedingung von städtischen Gebieten mit hoher Dichte unterscheiden sich diese Städte durch den Mangel an Straßen und Parkmöglichkeiten, den mangelhaften Öffentlichen Verkehr (ÖV), den schwach entwickelten motorisierten Verkehr, die Verkehrsprobleme - insbesondere Unfälle, Stau und die Umweltverschmutzung - sehr und mit zunehmender Verschärfung von höher entwickelten Städten. Da vom Motorrad abhängige Städte nach wie vor arm sind und Zielkonflikte bei der Verwendung der begrenzten Ressourcen bestehen, können diese Städte nicht im Traum daran denken, über ein in höher entwickelten Städten übliches auf den Pkw oder auf den ÖV ausgerichtetes Verkehrssystem zu verfügen.

Für die Vision einer lebenswerten Stadt mit einem nachhaltigen Verkehrssystem ist ein Verkehrsmanagementkonzept ein entscheidendes Hilfsmittel für den kurzfristigen Umgang mit Verkehrsproblemen in vom Motorrad abhängigen Städten, während Lösungen in Bezug auf Infrastruktur und den ÖV langfristig ausgelegt sind. Dieses Konzept basiert auf einem strategischen Rahmen, in welchem eine Rangordnung von Vision, Leitlinien und Zielen vollständig formuliert ist.

Geeignete Maßnahmen werden ausgewählt durch Festlegen und Anwenden eines multikriteriellen Bewertungsmodells, durch welches die Effektivität von Maßnahmen bewertet werden kann bezüglich der Erreichung der folgenden Ziele für ein nachhaltiges Verkehrssystem: 1. Sicherung städtischer Mobilität, 2. Sicherung der städtischen Verkehrssicherheit, 3. Schutz der städtischen Umwelt und 4. Verbesserung der städtischen und regionalen Wirtschaft. Die Umsetzbarkeit der Maßnahme wird indirekt bewertet durch den Schwierigkeitsgrad bei der Überwindung von vier grundlegenden Grenzen: 1. Kosten der Maßnahme, 2. technische Systeme, 3. Beteiligung von Einrichtungen und 4. Akzeptanz der Öffentlichkeit.

Nach der Bewertung wurden 34 potenzielle Maßnahmen in vier Gruppen eingeteilt, von denen die am höchsten priorisierte Gruppe grundsätzlich für die Anwendung in vom Motorrad abhängigen Städten empfohlen wurde. Diese Gruppe enthält 15 hoch-wirksame und anwendbare Maßnahmen des Verkehrsmanagements für fünf verschiedene Gruppen von Verkehrsmitteln: Für den Öffentlichen Verkehr werden fünf Maßnahmen empfohlen: 1. Verbesserung der Routenführung, 2. Verbesserung des Fahrplans, 3. Schaffung von Anreizen zur Nutzung des ÖV, 4. Informationsdienste für den ÖV und 5. Betriebsleitzentrale für den ÖV. Drei Maßnahmen für den nicht-motorisierten Verkehr sind Gehwege und Fußgängerüberwege, Bereiche für nicht-motorisierten Verkehr sowie Informationsdienste für den nicht-motorisierten Verkehr. Die zwei Maßnahmen für den MIV (Motorisierten Individualverkehr) sind Kraftfahrzeugsteuern und Gebühren sowie die Einflussnahme auf die Registrierung von Fahrzeugen. Für den verkehrsmittelübergreifenden Verkehr wurden vier

Maßnahmen ausgewählt: Lichtsignalsteuerung an Knotenpunkten, Verkehrsberuhigung und Geschwindigkeitsbeschränkungen, Informationssystem für den städtischen Verkehr, Beeinflussung der Flächennutzung. Schließlich ist ein City-Logistik-System die einzige Verbesserungsmaßnahme für den Wirtschaftsverkehr.

Es wurde ein zweistufiges Modell zur Strategieentwicklung eingeführt, um die umsetzbaren Maßnahmen zu Strategien zusammenzufassen. Zwei wichtige Prinzipien, die bei der Integration von Verkehrsmanagementmaßnahmen befolgt werden müssen sind 1. die Erreichung von Synergieeffekten und 2. die Reduzierung oder Beseitigung von Widerständen bei der Umsetzung. Vier grundlegende Maßnahmen des Verkehrsmanagements wurden formuliert. Die **Strategie zur Verkehrsvermeidung** enthält zwei Verkehrsmanagement-maßnahmen, *Änderung der Flächennutzung* und *City Logistik*, welche als grundsätzliche Maßnahmen der Strategie definiert wurden. Die **Strategie zur Verkehrsverlagerung** enthält zehn grundsätzliche Maßnahmen, von denen fünf ÖV-Maßnahmen (*ÖV-Routenführung*, *ÖPNV-Fahrplan*, *Anreize für ÖV-Nutze*r, *ÖV-Informationen*, *Betriebsleitzentrale*), drei Maßnahmen für den nicht-motorisierten Verkehr (*Einrichtungen für Fußgänger*, B*ereiche für nicht-motorisierten Verkehr*, *Informationen für nicht-motorisierten Verkehr*) und zwei MIV-Maßnahmen sind (*Steuern und Gebühren*, *Einflussnahme auf die Registrierungen*). Nach einer Bewertung der Potenziale unterstützender Maßnahmen wurde die Lichtsignalsteuerung zur Unterstützung der Knotenpunktbeeinflussung gewählt. Die **Strategie zur Verkehrslenkung** enthält fünf grundsätzliche Maßnahmen, von denen eine Maßnahme auf den nicht-motorisierten Verkehr abzielt (*Einrichtungen für Fußgänger*), eine Maßnahme auf den MIV (*Einflussnahme auf die Registrierungen*) und drei Maßnahmen auf den verkehrsmittelübergreifenden Verkehr (*Lichtsignalsteuerung*, *Verkehrsberuhigung*, *Verkehrsinformation*). Die **Strategie eines Integrierten Verkehrsmanagements** enthält 17 Maßnahmen des Verkehrsmanagements: 15 grundsätzliche Maßnahmen dienen der Beeinflussung des städtischen Verkehrs in allen drei Bereichen: Verkehrsvermeidung, Verkehrsverlagerung und Verkehrslenkung. Es wurde die Einbeziehung von zwei wirtschaftlichen Maßnahmen, *Straßenbenutzungsgebühren* und *Parkraumbewirtschaftung* als unterstützende finanzielle Maßnahmen für diese Strategie empfohlen.

Schließlich wurden Empfehlungen für die Umsetzung der Strategien und Maßnahmen des Verkehrsmanagements in Hanoi, Vietnam formuliert. Die städtischen Verkehrsverhältnisse in Hanoi wurden für vier typische Situationen beschrieben: **1. den Ballungsraum**, **2. das Stadtzentrum**, **3. die Hauptverkehrsstraßen** und **4. nur für Zweiräder zugängliche Viertel**. In Bezug auf diese Situationen wurden die Einsatzmöglichkeiten der vier typischen Verkehrsmanagementstrategien untersucht:

Die **Strategie zur Verkehrsvermeidung** ist im **Ballungsraum** und im **Stadtzentrum** von Hanoi in einem großangelegten und mittelfristigen Plan umsetzbar. In kleinem Umfang und kurzfristig kann diese Strategie in den **nur für Zweiräder zugänglichen Vierteln** effektiv angewendet werden.

Die **Strategie zur Verkehrsverlagerung** kann in großen städtischen Gebieten, im **Ballungsraum** und im **Stadtzentrum**, angewendet werden, wobei die nachgeordneten Situationen, die **Hauptverkehrsstraßen** und die **nur für Zweiräder zugänglichen Viertel**, inbegriffen sind.

Die **Strategie zur Verkehrslenkung** kann in allen vier Situationen umgesetzt werden und ist die wichtigste Strategie, die für die **Hauptverkehrsstraßen** und die **nur für Zweiräder zugänglichen Viertel** empfohlen wird.

Die **Strategie eines Integrierten Verkehrsmanagements** ist für die Anwendung im **Ballungsraum** von Hanoi geeignet. Vereinfachte Varianten können im **Stadtzentrum** Anwendung finden.

Diese Empfehlungen enthalten außerdem eine kritische Auseinandersetzung mit der Umsetzung der höchst priorisierten Verkehrsmanagement-Maßnahmen.

Bezüglich des Umfangs der Umsetzung sind sieben Maßnahmen in einer verkehrsmittelübergreifenden Strategie voll umsetzbar. Elf Maßnahmen sind verkehrsmittelbezogen voll umsetzbar, zwei weitere sind teilweise umsetzbar in einem verkehrsmittelübergreifenden Ansatz. Zehn Maßnahmen können angewendet werden bei einzelnen Einrichtungen oder Elementen bestimmter Verkehrsmitteln.

In Bezug auf den Ort der Umsetzung, außer in den nicht-motorisierten Zonen, sind alle Maßnahmen voll anwendbar auf den **Ballungsraum**. Zwölf Maßnahmen sind voll anwendbar im **Stadtzentrum**, während nur sieben Maßnahmen vollständig angewendet werden können entlang der **Hauptverkehrsstraßen** und sechs Maßnahmen in den **Zweiräder-Vierteln**.

Zur Einführung dieser Maßnahmen sind das Amt für Verkehr und städtische Angelegenheiten und Dienstleistungen sowie dessen nachgeordnete Büros die Schlüsselbehörden für die Planung, die Ausschreibung und den Betrieb der Maßnahmen.

Für die Durchsetzung und die Kontrolle der Lichtsignalsteuerung ist das Büro der Verkehrspolizei in Hanoi die verantwortliche Institution.

Bezüglich des ÖPNV ist das Verkehrsunternehmen in Hanoi (TRANSERCO) der wichtigste Akteur für den Personen- und Wirtschaftsverkehr.

Die wichtigsten politischen Entscheidungsträger in Hanoi sind das Volkskomitee von Hanoi und der Volksversammlung von Hanoi. Die mächtigste Einrichtung ist schließlich das städtische Komitee der Kommunistischen Partei.

Die wichtigste Erkenntnis ist, dass das Verkehrsmanagementkonzept, welches einen strategischen Rahmen (Ziele) und die Verkehrsmanagementstrategien und –maßnahmen (als Hilfsmittel) enthält, sowohl in vom Motorrad abhängigen Städten als auch in anderen sich entwickelnden Städten in Asien und anderen Gebieten weitgehend umgesetzt werden kann.

Außerdem sind das Bewertungsmodell für die Maßnahmen und das Modell zur Strategieformulierung anwendbar. Diese können weiterentwickelt werden zu einem umfassenden und quantitativen Modell und Untermodellen.

Die Empfehlungen für die Anwendung der Strategien und Maßnahmen in Hanoi sollte schließlich bis zur Umsetzungsreife weiterentwickelt werden.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

General Terminologies

BO	Bus Ownership
CO	Carbon Monoxide
CO2	Carbon Dioxide
dBA	A-Weighted Decibel
DS	Difficulty Score
ES	Effectiveness Score
GPS	The Global Positioning System
GRP	Gross Regional Product
HC	Hydro Carbon
IMV	Individual Motorised Vehicle
IT	Information Technology
MC	Motorcycle
MCO	Motorcycle Ownership
MDC	Motorcycle Dependent City
MRT	Mass Rapid Transit
NO	Nitrogen Monoxide
NO2	Nitrogen Dioxide
NMT	Non-motorised Transport
PC	Passenger Car
PCO	Passenger Car Ownership
PTDP	Public Transport Development Plan
RND	Road Network Density
ROA	Road Occupancy Area
SO	Sulphur Monoxide
SO2	Sulphur Dioxide
SPF	Strategic Policy Framework
SPM	Suspended Particulate Matter
TVO	Total Motorised Vehicle Ownership
TDM	Transport Demand Management
TDP	Transport Development Plan

TMP	Traffic Management Plan
UMP	Urban Master Plan
URT	Urban Rail Transit
UTDP	Urban Transport Development Plan
VO	Vehicle Ownership

Country and Institution

ADAC	Allgemeiner Deutscher Automobil-Club e.V.
APEC	Asia-Pacific Economic Cooperation
CAAV	Civil Aviation Authority of Vietnam
DfT-UK	Department for Transport of United Kingdom
DOF	Hanoi Department of Finance
DONRE	Hanoi Department of Resources and Environment
FGSV	Forschungsgesellschaft für Straßen- und Verkehrswesen
Georgia IT	Georgia Institute of Technology
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HAIDEP	The Comprehensive Urban Development Programs in Hanoi Capital City
HAPC	Hanoi People Committee
HAPI	Hanoi Department of Planning and Investment
HOPC	Hochiminh City People Committee
HPS	Hanoi Department of Public Security
HRS	Hanoi Railway Station Company
HOUTRANS	The Study on the Urban Transport Master Plan and Feasibility Study in Hochiminh Metropolitan Area
HUPA	Hanoi Urban Planning and Architecture
HUTC	University of Transport and Communication in Hanoi
ITE	Institute of Transportation Engineers
JICA	Japan International Cooperation Agency
MOE&F-India	Ministry of Environment and Forest of India
MOC	Ministry of Construction of Vietnam
MOF	Ministry of Finance of Vietnam
MONRE	Ministry of Resources and Environment of Vietnam

MOT	Ministry of Transport of Vietnam
MPI	Ministry of Planning and Investment of Vietnam
MPS	Ministry of Public Security of Vietnam
NAA	Noibai Airport Authority
NHTSA	National Highway Traffic Safety Administration
OECD	Organisation for Economic Co-operation and Development
PADECO	PADECO Limited Company
PCW	People Committee of Ward
TDSI	Transport Development Strategy Institute
TEDI	Transport Engineering Design Incorporated
TIMB	Transport and Industry Management Bureau
TOC	Taxi Operation Company
TPB	Hanoi Traffic Police Bureau
TPU	Traffic Police Unit
TRAMOC	Hanoi Urban Public Transport Management and Operation Centre
TRANSERCO	Hanoi Transport Corporation
TSCC	Hanoi Traffic Signal Control Centre
TUPWS	Hanoi Department of Transport and Urban Public Works and Services
UTI	Urban Transport Inspection
UTMB	Urban Transport Management Bureau
UTPMU	Hanoi Urban Transport Project Management Unit
UK	United Kingdom
UNEP	United Nations Environment Programme
USA	United States of America
VCP	Vietnam Communist Party
VDMB	Vehicle and Driver Management Bureau
VGA	General Assembly of Vietnam
VNR	Vietnam Railways Corporation
VRA	Vietnam Road Authority
VTV	Vietnam Television

1. Introduction

1.1. Backgrounds of the Study

In many cities of the South and Southeast regions of Asia, the urban transport system is dominated by motorcycles, for example, Hanoi, Hochiminh City, Surabaya, Jakarta, Bangkok, Chiang Mai, and many Indian cities (JICA and HAPC, 1997; Barter, 1999; BPS Indonesia, 2000; PADECO, 2000; Shah and Iyer, 2002; JICA, MOT et al., 2004; VTV, 2004). On the one hand, the tropical climate, high-density urban area, the lack of road hierarchy, and especially the reasonable price of motorcycles are the facilitators of this motorcycle domination in the city traffic. On the other hand, the use of motorcycles has significant influenced the urban form and land use pattern of the cities. The high accessibility and mobility of motorcycles enhance the oil-stain sprawling of the urban area without needs of the car-based roads and parking places. In addition, the irregular housing development and the lack of land use control are also important factors for the existence of many two-wheels accessed only blocks and motorcycle dependent urban land uses (JICA, MOT et al., 2004; Pucher and Korratyswaroopan, 2004).

This image of motorisation with low car use is defined as motorcycle dependence and it is unique in these cities, and has never existed or been realised in the others. Such urban areas are defined as motorcycle dependent cities as the similar concept of automobile dependent or transit-oriented cities (Kenworthy and Laube, 1999).

Although manifested transport problems in the motorcycle dependent cities are addressed similarly as in other cities of the world by the conventional terms of severe road accident, traffic congestion and environmental pollution, the uniqueness of motorcycle dependence makes these problems very different from and much more complicated than that in the car dependent or transit-oriented cities.

The study area is focused on the Asian cities, which, in the early of 2000s, are still at low and low-middle-income level, which are able to support a high rate of motorcycle ownership. In order to define the motorcycle dependence and to identify the transport problems of the MDCs, comparisons have been made between six Asian cities, which have differences in income levels, but share relative high level of motorised vehicle ownership. In addition, data of developed cities are referred to when necessary to clarify the differences.

Although the traffic management solutions in this study are recommended for the motorcycle dependent cities, one can recognise that many solutions were originated in the developed cities; some of them came from the developing cities that are in different situations of urban transport, and some were developed in the motorcycle dependent cities. Therefore, the solutions can also be referred to in the studies for recommendations to other types of developing and developed cities.

In this chapter, the main motivations and significances of this study are addressed. Then the goals and objectives of this study are presented as the responses to a series of research questions. The scope and limitation of the study are also discussed, followed by an overview of the structure of thesis and a brief description of the contents and methodology of each chapter.

1.2. Motivations and Significance of the Study

This sub-chapter outlines the significance of the topic and the main motivations for the researcher to undertake this study and to endeavour the research questions stated in the sub-chapter 1.3 below. Answers to the questions raised in this thesis have a bearing on the quality of life of many millions of people who live today and tomorrow in the low-income urban areas, and on potentially large environmental impacts on local, regional and global scales.

1.2.1. An Unique Situation of Urban Transport System

So far, no city in America, Europe, Australia, or Africa has a value of motorcycle ownership higher than 100 motorcycles per thousand inhabitants. Textbooks in history of urban transport in Western countries (Vuchic, 1981; Steierwald and Künne, 1994), never mention the motorcycle as a common transport mode. In contrast, many Asian cities have relative high level of motorcycle use. Tokyo (Japan), Singapore, Hong Kong and some other cities have the motorcycle ownership (MCO) of about 100 motorcycles per 1000 inhabitants during 1980s (Barter, 1999). Bangkok, Kuala Lumpur, Jakarta and many Indian cities have MCOs of about 150 to 200 motorcycles per 1000 inhabitants. Currently, some cities have MCOs of higher than 300 motorcycles per 1000 inhabitants, for example Chiang Mai (Thailand), Surabaya (Indonesia), Taipei (Taiwan-China). Especially, there are cities that have MCOs of higher than 400 motorcycles per 1000 inhabitants, for example, Hanoi, Hochiminh City (MOT Vietnam), and Kao-Hsung (Taiwan-China).

In the middle- or high-income cities, for example, Taiwanese cities, Bangkok, Kuala Lumpur, the public transport and cars are currently acting as a very strong competitor to the motorcycle. These cities are not in the situation of high motorcycle dependence. On the other hand, in the lower income cities, for example, Hanoi or Hochiminh City, and many other Asian Cities with poor public transport service, expensive cars and taxis, slow bicycles, motorcycles play an outstanding/ a dominant role in the urban transport system. People drive motorcycles for almost every activity. New automatic transmitted motorcycles of Honda, Piagio, and Yamaha, etc. are regarded as symbols of wealth and modern life-style of the young generation. Those images made the first motivation for a study that tries to define the *motorcycle dependence* situation by proper terminologies, criteria, based on revealed data and information.

1.2.2. Urban Transport Problems and Opportunities

Unsustainable transport is one of the biggest threats to the future of the ecosystem in urban areas, countries, and the world as a whole. The high level of dependence on automobile in the developed countries has been worrying for long time. Recently, the world is seriously witnessing the explosive motorisation in the Asian countries and many believe that the doomsday would come when Chinese and Indian people can afford the level of car ownership as in European or North American countries.

The high level of motorcycle dependence of the city contains also serious transport problems that are manifested from serious situation of accidents, congestion, and pollution. The increase of motorcycle use means a reduction in non-motorised transport modes. The mix of different vehicle generations and technologies in the traffic, especially the high-speed conflicts between the dominating motorcycles and four-wheelers on the car-based roads (and/or non-standard roads) with car-based control technologies are causing high rates of accident and fatality on the urban roads. The extreme high motorcycle volume creates much difficulty for operation of the bus-based public transport.

Another issue is that the high-density urban area exists together with the poor public transport services, and the lack of fundamental urban road infrastructures (roads and parking places). The two-way accessed residential blocks are almost out of the conventional emergency services and other essential services that require four-wheelers accessibility.

The immaturity of the society is also a big challenge that shows bad users' behaviours and lack of awareness of transport problems. Many people and decision makers strongly believe that the shifting from motorcycles to cars in transport is not only the unavoidable way of human life progress, but also the best solution to urban transport problems. This attitude is well understood by car manufacturers, who are trying to lobby and force the decision makers in the field of transport to agree to the private car-preferred policies.

In contrast, the high density of urban area and the reasonable traffic flow quality and very short travel distance of people (e.g. in Hanoi, Hochiminh City) should be considered as an opportunity to save land area, and energy for transport performance. Recently, the shifting of some Americans and Europeans from using cars in response to the gasoline price should be considered as a way to save our limited fossil fuel (NHTSA, 2003). A one hundred cubic centimetres and four-cycle engine motorcycle (e.g. Honda Dream II) consumes only less than 2 litres of gasoline for one hundred kilometres of operation. It can run safely with a speed of ten to fifteen kilometres per hour (kph) in an alley or sixty to eighty kph on a rural highway.

Fortunately, the safe motorcycle traffic in the cases of Taipei and many other Taiwanese cities proved a way to deal with this problem. The solutions for reduction of air and noise pollutions of motorcycle are potential. The new model four-strokes engine motorcycles are much calmer and cleaner than the conventional two-strokes engines. The various models of small size motorcycles are presented also as possible solutions to urban environment.

1.2.3. Relevance of Traffic Management for Motorcycle Dependent Cities

Although the author agrees to a certain extent with many arguments that the best long-term strategic approach of urban transport system is a balanced transport system based on public transport, the primary motivation of this study is to develop a comprehensive traffic management concept as the centre of urban transport development in MDCs. The heavy infrastructure and mass transit would be then developed as basic requirements of traffic management measures.

In their publication on sustainable urban transport strategies, Newman & Kenworthy (1999) and Vuchic (1999) proved that the liveable European cities would not be realised if they could not successfully implement traffic management measures. In an Asian focused study, Barter (1999) concluded that traffic management significantly contributed to the successes of Singapore and Hong Kong or Seoul. Some comprehensive studies concluded that the possibility of success for developing a transit oriented city would be more significant if the traffic management measures could be applied as soon as possible before the private car ownership reaches the value of 100 to150 cars per 1000 inhabitants (Barter, 1999; PADECO, 2000). Lack of consideration for traffic management will lead the cities to either traffic saturated cities (e.g. Bangkok, Jakarta, or Manila) or automobile dependent cities, as the cases of American or Australian cities.

The situation of having a motorcycle ownership (MCO) of 300 to 450 per 1000 inhabitants, plus a passenger car ownership (PCO) of about 50 to 100 per 1000 inhabitants, as in the motorcycle dependent cities, presents a big challenge to the future development of a transport system. The study of Barter (1999) implied that without strong and committed traffic management strategies, the motorcycle dependent cities would become traffic saturated and further get into the situation of traffic disaster.

The motivation here is to establish effective traffic management strategies, which need proper traffic management measures for building-up their content and translating the overall strategic policy framework into specific action plans. Therefore, this study is looking for a catalogue of measures, which will be clearly defined by their technical contents, nature of impacts, and the applicability in the conditions of MDCs. This catalogue will later become the main source to formulate different traffic management strategies.

In addition, the study was conducted with a hope that its findings would be beneficial for other low-income developing cities in Africa, and Asia where the urban transport is still underdeveloped, although the differences in social-cultural and urban structures may require many adjustments and modifications. Furthermore, it is a motivation to propose a possible application of the traffic management strategies and measures for a typical MDC. Therefore, Hanoi (Vietnam) is selected as the case study.

1.2.4. Lack of Information and Research of Traffic Management in MDCs

In Asia, where all motorcycle dependent cities are located, there are a number of studies on motorcycles in countries like Japan, Taiwan, India or Vietnam, but most of them are focused in specific aspects, for example, the motorcycle market survey (Nagai, Fukuda et al., 2003) , traffic safety (Du, 2002; Vi, 2002), calculating Passenger car equivalent of the motorcycle (Minh and Sano, 2003). Some studies have also been conducted on motorcycle traffic in Germany, United Kingdom and USA, but they focused on safety aspect. Moreover, these studies had been conducted with the primary assumption that motorcycle is a minor transport mode in the transport system.

On a strategic level, Barter (1999) was the only expert, so far, who defined the domination of motorcycles in the traffic flow by the term “motorcycle city.” He is also the only expert, who integrated the motorcycle city in an evaluation model of land use and transport. This model predicted that the best long-term solution for the motorcycle city is a transit city.

So far, there are only two studies, which examined the applicability of traffic management in the cities that have a relative high level of motorcycle use. Tanaboriboon (1992) reviewed the successes and failures of some traffic management measures in Asian metrologies (Singapore, Hong Kong and Bangkok) and then recommended a list of measures, which were strongly focused on the local conditions of Bangkok in the early 1990s. Hung (2000) conducted a specific evaluation of a traffic management package (bus encouragement and motorcycle pricing). However, the scale of this study is small and the results indicated only local conditions of an urban corridor in Hanoi. Therefore, the need of having comprehensive information and research about traffic management in MDCs is also one of the key motivations of this study.

1.3. Research Questions

The first focus of this thesis is to define the level of motorcycle dependence and its consequent transport problems and causes in the selected cities. The central part of this study is to establish a traffic management concept that helps the MDCs achieve a sustainable transport system. These issues have been brought into focus using a number of research questions that arose from the motivations raised in the previous section.

Research question 1:

What is state-of-the-art traffic management?

Research question 2

What is motorcycle dependence? What are transport problems and their causes in Motorcycle Dependent Cities?

Research question 3

What is a strategic policy framework for traffic management in Motorcycle Dependent Cities?

Research question 4:

What are possible traffic management measures that would be able to apply in the Motorcycle Dependent Cities?

Research question 5:

What are possible traffic management strategies that would be formulated in the Motorcycle Dependent Cities?

Research question 6:

How could the traffic management strategies and measures apply in a typical MDC?

1.4. Goal and Objectives of the Study

The overall goal of this study is to find out a Traffic Management Concept that proactively alleviates the urban and transport problems and aims to develop a sustainable urban transport system in the Motorcycle Dependent Cities (MDCs). This goal can be divided into the objectives as follows:

- Reviewing the traffic management state-of-the-art in order to found theoretical backgrounds for traffic management concept in the MDCs,

- Defining the motorcycle dependence of the cities and analysing and evaluating the traffic conditions of MDCs, in order to identify the transport problems and causes,
- Defining the goals and objectives of the traffic management toward a sustainable urban transport in the MDCs
- Selecting possible Traffic Management Measures for MDCs,
- Formulating possible Traffic Management Strategies for MDCs,
- Proposing a model of application in the experimental case study in Hanoi, Vietnam.

1.5. Scope of the Study

As defined by its goals and objectives, the research area of this study is limited within the boundary of Traffic Management Concept and its contents (Planning process, Measures, Applications and Strategies), which are appropriate for the urban transport problems in MDCs. Although traffic management can not be the single solution on the way to achieve a sustainable urban transport system, the infrastructure and public transport development solutions, such as urban road network construction and expansion or new urban transit services development are excluded and only referred to when necessary.

Within this study, a literature review is conducted to examine the application levels of traffic management measures, principles in formulating strategies, and approaches in planning traffic management activities in the traffic management pioneer-countries.

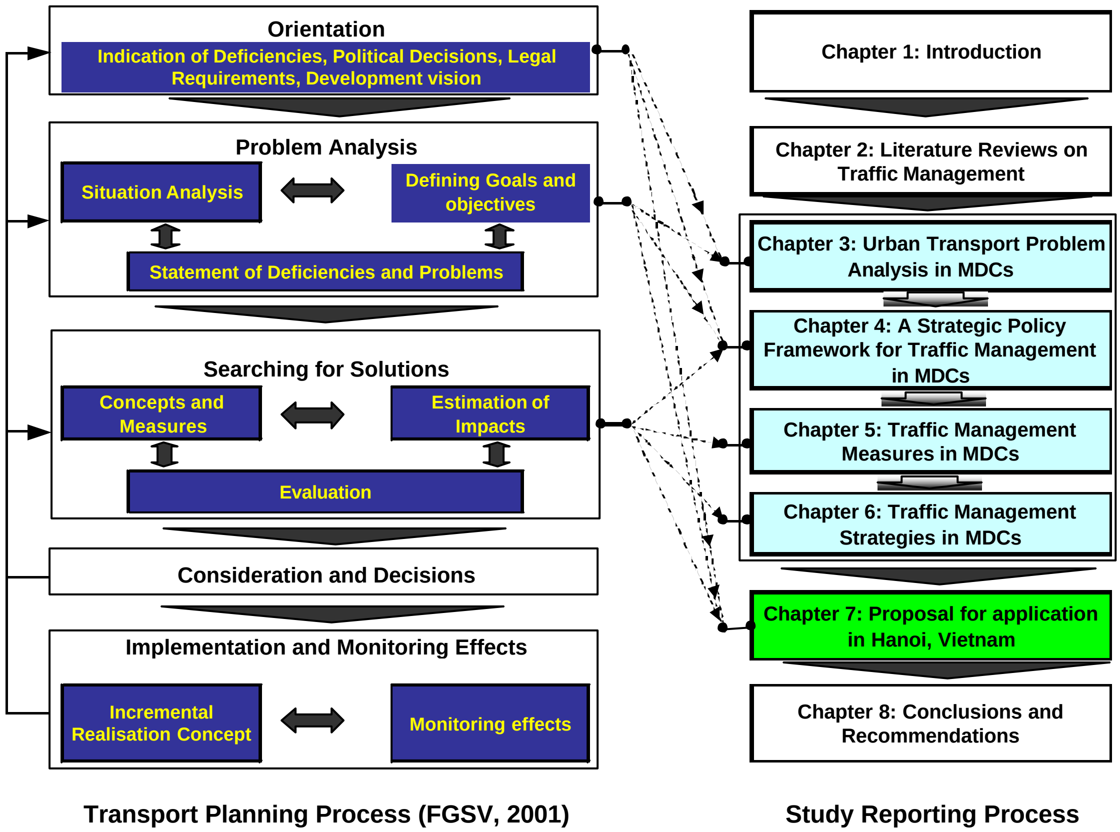
The focus in data collection is the general, large scale, citywide features of the transport and land use of some Asian cities, which were selected as the representative for different levels of motorcycle dependence. Furthermore, the data were collected only in the main conurbation of the cities. The satellite suburban centres are excluded from this study.

The first theoretical finding of this study focuses on having a catalogue of traffic management measures that would be highly applicable in the motorcycle dependent cities. The next is possible traffic management strategies that would be the key strategic approaches in application of traffic management measures. The practical finding focuses on a proposal about applications of traffic management strategies and measures to alleviate the specific transport problems in the case study, Hanoi, Vietnam. It is necessary to emphasize here that this study only provides the general concept and global direction impacts of the proposed traffic management measures and strategies, which should only be considered as a conceptual framework for further considerations and detail developments in the specific traffic management studies.

1.6. Methodology and Structure of the Study

The methodological approach of this study is based on the German Transport Planning Process (Retzko, 1992; FGSV, 2001). The structure of the chapters in this report also sequentially follows the phasing of the planning process.

The theoretical backgrounds for traffic management concept in MDCs are presented in Chapter Two, which include the definitions of traffic management, measure, strategy, and plan. These definitions have been consistently applied throughout the study. The current state of traffic management measures is examined on the aspects of categorisation, impact, and application level. In planning traffic management activities, the literature presents three different approaches: (i) integrated traffic management programs in the transport development plans, (ii) traffic management alternatives in the transport development plans, and (iii) a comprehensive Traffic Management Plan. The review also founds valuable recommendations about applications of multi-criteria models in assessment of traffic management measures. In the literature review chapter, two principles of formulating traffic



management strategies are also thoroughly discussed.

Figure 1-1:Methodology and dissertation structure

The urban transport problem analysis is conducted by examining the urban and transport conditions of six Asian cities. The cities were firstly selected according to the perspective of high level of motorcycle ownership. The second consideration was the income level, the sample should represent cities in low-, middle-, and high-income cities (see detail categorisation in Barter, 1999). The size and economic impact of cities were also considered. Among many cities, which fall in the range of these criteria, Hanoi, Hochiminh City (Vietnam), Bangkok (Thailand), Jakarta (Indonesia), New Delhi (India) and Taipei (Taiwan-China) were finally chosen according to the availability of data.

The collected data presented a macro level of transport situation and related urban development issues in the cities. Although qualified data on urban transport of MDCs are seldom provided in international publication media, in this study they were collected directly from the field study and from some personal contacts. Some statistic figures were referred from prevailing publications, official statistics, and from related agencies' documents. Some data were collected for first time, for example the household mobility condition in the motorcycle dependent city or the experts' opinions toward transport situation and traffic management measures in Hanoi.

Results of the urban problem analysis are presented in Chapter Three entitled Urban Transport Problem Analysis in MDCs. The definition of *motorcycle dependence* is firstly presented, as the unique characteristic of MDCs. This is followed by a section showing manifested transport problems (accident, congestion, and environmental pollution). Urban development and transport conditions were presented as the causes of urban transport problems in MDCs.

The urban transport analysis enlightened the need for a strategic policy framework (SPF). In general, this framework principally includes a long-term vision, strategic goals, objectives, and modal orientations for traffic management activities in a city. Specifically, a traffic management program will define its own strategic policy framework based on the principal SPF and specific objectives of the project. In Chapter Four, a principal strategic policy framework for Motorcycle Dependent Cities has been formulated.

The key step of searching for solutions is presented in Chapter Five. This step was conducted by the inventorying and assessing traffic management measures, which would be applicable in most of motorcycle dependent cities. Candidate measures are nominated according to the reviews of traffic management state- of-the-art in Chapter Two and the perception of traffic management application in MDCs in Chapter Three. A catalogue consists of candidate measures, which are then categorised by transport modes and further classified by their characteristics. The qualitative assessment has been employed to estimate the effectiveness and applicability of measures in MDCs. According to the assessment results, a rating system is employed to evaluate the measures. Finally, a list of fifteen first-priority measures is recommended for further formulation of traffic management strategies. These works are presented in Chapter Five and are considered as the main theoretical findings of this study.

In Chapter Six, typical traffic management strategies are formulated based on expected traffic impact, including (i) Traffic Avoiding Strategy, (ii) Traffic Shifting Strategy, (iii) Traffic Controlling Strategy, and (iv) Integrated Traffic Management Strategy. The formulation model has been established representing two principles of integration: (i) integration to achieve the synergic effectiveness, and (ii) integration to increase the applicability in the implementation of measures.

Chapter Seven reports on the proposal about applications of traffic management strategies and measures in Hanoi. In this case study, a general examination on urban transport conditions was conducted. Then, four typical transport situations in Hanoi were defined in spatial term, including overall conurbation, city centre, urban arterial, and two-wheeler accessed only block. Four typical Traffic Management Strategies were examined in terms of their applicability for the situations. Finally, the applications of first priority measures were also proposed in terms of strategic scale (general, modal, and unit), situations and responsible institutions.

2. Literature Review on Traffic Management

The purpose of this chapter is to draw a state- of-the- art picture about traffic management and its applications. First, it reviews some key definitions in the field of traffic management. Secondly, it provides a thorough review of the literature about current level of applications of traffic management measures and strategies. The next section presents the current state of planning traffic management activities. The last section discusses the basic requirements for planning and implementation of traffic management activities.

2.1. Key Definitions

- **Transport System**

According to Boltze (2003b), transport system consists of two transport forms, called passenger and commercial transport (as similar to the German term "Wirtschaftverkehr"). Underneath, the forms consists lower categories according to use and propulsion.

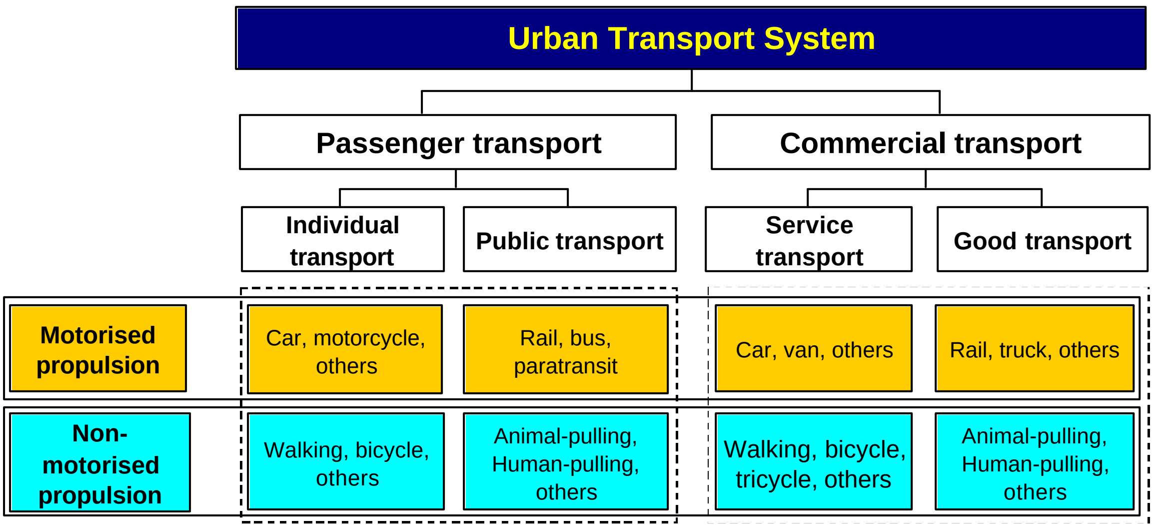
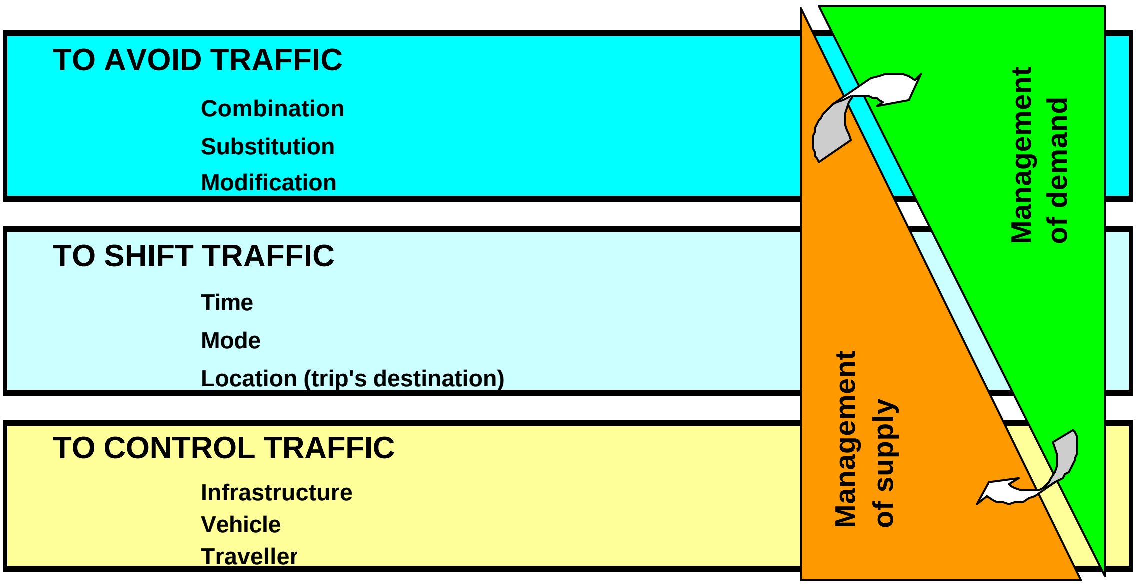


Figure 2-1: Urban transport system hierarchy

- **Traffic Management**

A review of literature in the field shows that the term **"traffic management"** is presented in different wordings, for example *Traffic Restraint* (Hitchcok, 1973), *Congestion Reducing* (C-R) (Remak and Rosenbloom, 1976), *Congestion Control* (Strickland and Berman, 1995), *Transport Demand Management* (TDM) (Tanaboriboon, 1992; Hung, 2000), *Road Travel Demand Management* (OECD, 2002), and *Mobility Management* (Littman, 2002), or *Transport System Management* (TSM) (Roess, Prassas et al., 2004).

These terminologies try to express the same content, that is **"to influence transport system with a bundle of measures to bring transport demand and supply in an optimised balance"** (Boltze, 2003a). As shown in Figure 2-2, Traffic Management includes a wide range of measures to avoid traffic, to shift traffic, and to control the traffic.



[Source: adapted from Boltze (2003a)]

Figure 2-2: Impacts of traffic management

- **Traffic Management Measures**

This study defines a traffic management measure as

> **"a set of activities that creates technical traffic management impacts toward desired improvements of a defined transport situation".**

There are different ways to categorise traffic management measures. The reviewed literature shows that three major ways classify the measures: (i) by characteristics of measures, (ii) by transport modes, and (iii) by combination of the characteristics and transport modes. In this study, traffic management measures are firstly categorised by desired impacts on transport modes. Under each modal category, measures are grouped by characteristics of measures.

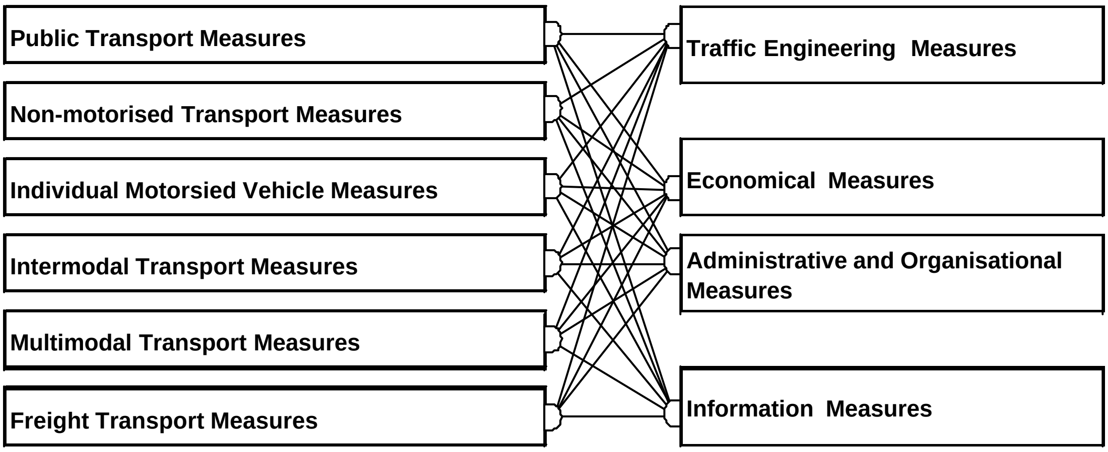


Figure 2-3: Categorisation of traffic management measures

Public Transport Measures focus on encouraging travellers to use public transport services (Albert Speer and Partner, 1993; ITE, Georgia IT et al., 1993; Littman, 2002; OECD, 2002). On the other hand, traffic management should encourage the operators to provide better quality and higher capacity public transport services.

Non-motorized Transport Measures focus on reservation right-of-way, provision sufficient facilities, information and safe environment for pedestrians and bicycle traffic.

Individual Motorised Vehicle Measures focus on optimisation uses of these modes. For motorcycles, measures focus on improving safety and reducing environmental impacts of the motorcycle. For private cars, measures emphasize on the minimising of car use.

Intermodal Transport Measures focus on provision and organisation of intermodal facilities, such as park and ride facilities, and other intermodal transport interchange points.

Multimodal Transport Measures aim to have multiple impacts on improvement of all related transport modes, for example intersection signal control.

Freight Transport Measures try to minimise and eliminate the conflicts in using infrastructures and services between freight transport vehicles and the passenger transport vehicles. In addition, the measures to reduce environmental impacts of freight transport are definitely required.

Traffic Engineering Measures deal with the engineering aspects of planning, geometric design and traffic operation of way (public transport line), interchanges, terminals, and abutting lands of different transport modes in the study area.

Economical Measures try to optimise the economic efficiency of available service capacity and resources in transport. These measures also provide mechanisms to ensure the economic equity of different groups in using public services and resources.

Administrative and Organisational Measures deal with legal and organisational basis for the development and operation of infrastructure (way, interchanges and control devices) and vehicles. They also deal with rights and responsibilities of users, operators, governmental agencies and other parties in the development and operation of a transport system.

Information Measures try to provide essential information of a transport system as required by users, operators, governmental agencies, and other parties, in order to improve the urban transport in the aspects of mobility, safety, environmental friendly, and efficiency.

- **Application of Measure**

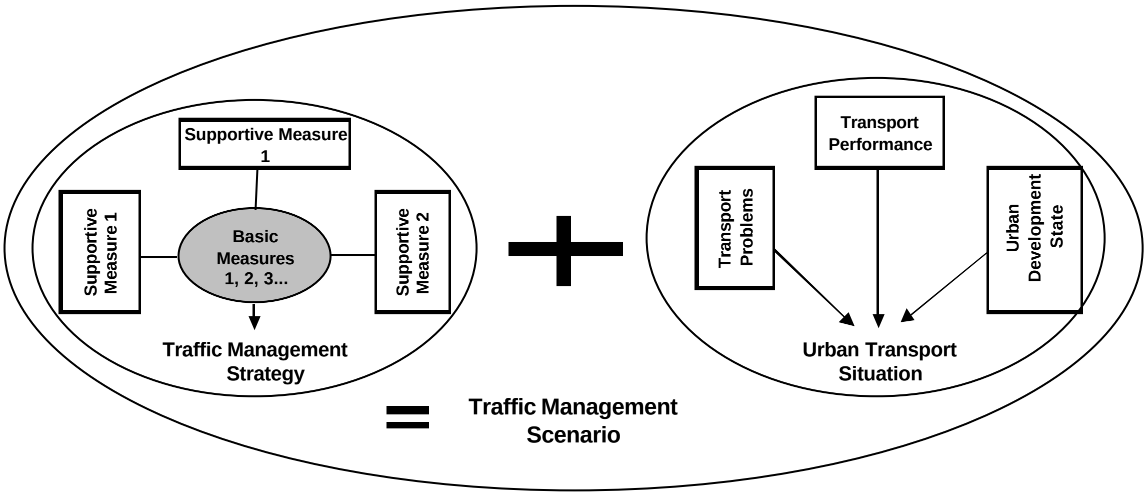
The term of “Application of Measure” is defined to express the specific realisation (e.g. specific technology) of a traffic management measure. For example, the road pricing measure can be implemented through a system of manual tollgates or an electronic road pricing system. Right selection of application is the key step before studying on production, productivity, cost, and benefits of a Traffic Management Measure.

- **Traffic Management Strategy**

In this study, the term **“traffic management strategy”** is defined in the following German Guidelines of Strategy Development for the Dynamic Traffic Management as:

> **“an integrated plan for implementation of a set of traffic management measures that aims to improve a specific (existing) situation of transport system, facility or service”** (adapted from FGSV, 2003)**.**

In other words, a traffic management strategy consists of **Basic Measures** and the other **Supportive Measures**, which provide background conditions (legal, technical, financial, organisational) for implementation of the measures. The relationship between a strategy and an urban transport situation is defined as a traffic management scenario, which is presented in Figure 2-4.



[Source: adapted from FGSV (2003)]

Figure 2-4: Traffic management strategy, situation, and scenario

The key criteria should be taken into account when formulating a traffic management strategy are direct *traffic impact* and *spatial scale* of the impact.

In terms of traffic impact traffic strategies can be formulated in one of the following four categories.

Traffic Avoiding Strategy includes measures that aim to reduce absolutely the traffic demand in the targeted urban area. The generated traffic demand (number of trips) is the main criterion to examine the traffic impact of this strategy.

Traffic Shifting Strategy includes measures that aim to shift the traffic demand between different mode, time, destination, and route of the trips. The modal split, time distribution of demand and the change in Origin-Destination transport demand are the main criteria to examine the traffic impact of this strategy.

Traffic Control Strategy includes measures that aim to assign the ROW for drivers/travellers and thus to facilitate the traffic safety and to maximise the use of the available ROW by ensuring orderly and predictable movement of all traffic on the roadway (Garber and Hoel 2000). Traffic volume and volume-capacity ratio are the main criteria to examine the traffic impact of this strategy.

Integrated strategy includes the measures of traffic avoiding, shifting and controlling. The traffic impacts of this strategy are examined by generated traffic demand, modal split and traffic volume at the targeted location.

Regarding the spatial scale, urban traffic management strategies can be formulated in one of three categories or levels.

General Strategy generates impacts to all urban transport modes.

Modal Strategy generates impacts to specific urban transport mode(s).

Unit Strategy generates impacts to specific facility or service unit(s).

- **Traffic Management Plan**

Bohlinger (2006) defined Traffic Management Plan (TMP) as a new type of plan in the transport planning system. Although no specific definition of Traffic Management Plan was presented, one can understand his implication about that instrument as follows:

> **A Traffic Management Plan includes a set of traffic management measures with the associated time schedules, resources, and personnel needed to perform all tasks required to achieve the predefined goals and objectives.**

For the cities, the TMP is expected to apply to all three levels (Level 1: intermodal and multimodal network, Level 2: single modal network, Level 3: single unit) of urban transport planning system. Furthermore, the researcher mentioned the need to have a regional TMP, which could coordinate the TMPs of different cities and communities within the region. However, no Traffic Management Plan has been realised as what is defined above.

2.2. Traffic Management Measures and Strategies

2.2.1. Development of a Traffic Management Concept

The conventional thinking about traffic management measures was simply the application of traffic control devices in order to perform traffic regulation and road operation. Since 1970, the concept of “predict and provide” in transport planning and development was step by step replaced by the concept of “predict and manage”. Along with the development of new concept, many new traffic management approaches and measures have been adopted and implemented. Marshall and Banister (2000) divided the individual traffic management measures into two groups: conventional measures and innovative or dedicated measures.

- **Conventional Traffic Operation and Control Measures**

Whenever and wherever a traffic problem (traffic congestion, accident, or pollution, and etc.), occurs, traffic operation and control measures are appreciated as the first and the most popular option of the authorities, operators and users. According to Matson, Smith et al. (1955), traffic operation and control measures are defined in four major areas as follows:

- *Vehicle control* includes the regulation and enforcement of registration, ownership, mechanical fitness, accessories, size, weight, and emission rate of vehicles.
- *Diver control* includes the regulation and enforcement of human physical conditions and ability to operate certain type of vehicles (licence), insurance responsibility and so on.
- *Roadway* control includes the regulation and enforcement of design standards for traffic features of roads, for example lane width, gradient, curvature radius etc.
- *Flow control* includes the regulation and enforcement of driving direction, right of way, speed, headway, schedule (for public transport vehicle) etc.

In a systematic approach, operation and control measures are planned and designed in the new development or major improvement of the infrastructure and services. The measures are applied via provision of traffic control devices (e.g. road markings, traffic guidance and regulated signs, traffic signal systems, parking control systems, and policemen) or operation regimes (serviced time, schedule, frequency, stop's location) of public transport services. The daily traffic operation and control service try to maintain a certain level of traffic performance according to traffic laws, regulations, standards and technical specifications of the infrastructure and vehicle operation regimes.

- **Dedicated Traffic Management Measures**

The increase of complexity and scale of transport problems is the main reasons for the invention and application of the new traffic management measures, for instance, Road pricing, Land Use Management, Intelligent Transport Systems, and etc. Today, the term "**traffic management**" is commonly understood as the applications of dedicated measures, which are accounted for approximately seventy to eighty measures,.

In 1971, the OECD's "Symposium on Techniques of Improving Urban Conditions by *Restraint of Road Traffic*" in Köln (Germany) discussed for the first time about four measures, Traffic Cells, Transit Priority Lanes, Parking Controls, and Road Pricing (Kreil, 1973).

Five years later, Remak and Rosenbloom (1976) introduced a catalogue of twenty two traffic management measures that were implemented in eighteen cities in USA in 1970s. After that, Strickland and Berman (1995) provided a list of thirty-five different traffic management measures, which are implemented in the OECD countries (see Table A-2, Annex A).

Marshall and Banister et al. (1997) counted about 64 different traffic management measures, that were implemented in eight European countries between 1985 and 1995. Although the most advanced traffic management application may not be implemented in Europe yet, several European cities are currently leading the world in terms of sustainable transport achievement through various types and levels of traffic management measures, as the outcome of their continuous efforts, (Newman and Kenworthy, 1999; Vuchic, 1999; OECD, 2002).

Currently, the developed countries focus on the advanced dynamic traffic management measures, especially the Intelligent Transport Systems (e.g. electronic tolling systems in Singapore or London, or the GPS based German Truck Tolling System, Public Transport Management Centre in Berlin etc.). The real-time passenger information systems are widely applied for public transport service in many European and American cities. For example, the ADAC's survey in Transport Telematics in 251 German cities in the year 2000 found that 63% cities provided public transport pre-trip information service, 55 % cities provided electronic payment service, 47% cities had the central public transport management or information system, 37% cities had dynamic parking control service (ADAC, 2002).

Asian cities are also proud of some successes in the application of traffic management measures. The area traffic tolling system was firstly applied successfully in Singapore (Gomez-Ibanez and Small, 1994). The Japanese cities are recognised as the most advanced in applying intelligent traffic management (Miles and Chen, 2004).

American experts thought Traffic Management was originally developed in the USA, and they point out many examples of traffic management applications in the US cities. However, the worldwide recognitions of success in this continent are the belongings of the Latin American cities. Two famous examples are Curitiba (Brazil), with the corridor development measure (Petersen, 2002), and Bogotá (Columbia), with the non-motorised transport prioritisation.

2.2.2. Application Levels of Traffic Management Measures

- **A Worldwide Overview**

As mentioned above, the OECD's Symposium in Köln in 1971 synthesised for the first time the theoretical backgrounds, experiences and practical applications of four major recommended measures named Traffic Cells, Transit Priority Lanes, Parking Controls, and Road Pricing (Kreil, 1973), which were considered as measures to restraint private car traffic. These four initiatives are still presented today as the major and the most popular traffic management measures over the world. The conclusions on the traffic management state in the pioneer countries at that moment were:

- *United Kingdom*: pure welfare economic approach,
- *France*: emphasis on self-financing new transport facilities,
- *Germany:* no distinct approach; alternative suggestions emphasising a number of theoretical difficulties,
- *United States*: several different and more localised criteria with special emphasis on the welfare of those people to whom city representatives are responsible.

This synthesis also presents the operational and control characteristics of traffic management in the early 1970s. Except *Road Pricing*, other measures are in the area of conventional traffic control and operation.

About twenty years later, Strickland and Berman (1995) reported on the applications of thirty five traffic congestion reduction measures, which were applied in OECD countries until the mid-1990s. The authors classified the measures into two groups: d*emand management* and *supply management*. Under these two major categories, the measures were allocated into nine groups, called "strategy classes". State of application of measures has been indicated by three levels: significant application, some application, and no application. The area, time, and some other criteria of the applied situation were also reported.

Recently, OECD (2002) introduced 112 examples of successful measures in all OECD countries in order to prove, by evidences, that traffic management strategies are considered equally as the infrastructure development strategies in these countries. On the other hand, OECD (2002) identified some general challenges in the application of traffic management measures. These include public awareness of problem, political leadership, and general support of economics and other measures, vertical and horizontal coordination between institutions, participation of private sectors and individual travellers. In addition, the changes of legal conditions and even the establishment of a new government and social institutions are necessarily required, in many cases, for successful implementation of the measures.

- **United States**

Traffic management was initiated quite early in the USA, but the remark about *local focus* of Kreil (1973) still remains. Traffic Management in the USA has been applied mostly at the employment sites under programs that were implemented by employers and the key actor. The focuses of the US traffic management programs are solo-driving commuters or working travel demand to individual employment sites other than a broader view to different travellers in a city or on a regional scale.

Remak and Rosenbloom (1976) introduced seventeen *peak-period congestion reduction techniques*, which could be to applied either individually or in one of the eight packages (see Figure 2-5 in section 2.2.3). Three years late, these authors discovered that only six of eight proposed packages (except *Land use change* and *Communication Substitutes of Travel* package) and a new adopted one (High-Occupancy Vehicle Priority) had been actually implemented (Remak and Rosebloom, 1979).

In the study on *Implementing Effective Travel Demand Management Measures,* ITE, Georgia IT et al. (1993) found that traffic management programs at employment sites were very effective. These programs could reduce vehicle trips as much as thirty to forty percent in relation to specific situations. In contrast, the area-wide traffic management programs are not likely to achieve a good result in vehicle trip reduction (only four to eight percent), but *"area-wide mandates for trip reduction are important for stimulating employer trip reduction programs"*. The other finding is that only three (out of twenty-two) investigated trip reduction programs did not require legal improvements. Therefore, it concluded that a success traffic management program requires four basic factors: ***commitment, constituency, coordination,*** and ***continuity***. Moreover, the key challenges for successful implementation of any traffic management program are achievement of ***motivation, empowerment,*** and ***perception.***

- **European Countries**

In a study through seven European countries, Marshall and Banister et al. (1997) found sixty four *travel reduction* measures (classified into ten categories) had been implemented in these countries so far, but the levels of application at that time still ranged between low (a few pilot projects) and medium. The authors also presented some primary assessment results of the measures. The results indicated that, the *traffic shifting* impacts (by transport mode, trip destination and time) are frequently observed (77% of total investigated applications) than the *traffic avoiding* impacts (combining trips, travel substitutions, and trip form modification). From the observations, the authors drew several conclusions as follows:

- The measures will be expected to have different levels of importance in terms of their impact on travel reduction.
- There would not necessarily any universally application strategy, although individual measures might feature strongly in many different strategies.
- Beside the need to improve the commitment of local and central governments in planning and implementing traffic management strategies, there is need to coordinate

the responsibility and efforts not only from governmental institutions, but also from private organisations.

- One of the key points for success is the traffic management strategy, which related firms, and individuals need to be aware of and actively involved in.

Recently, Marshall and Banister (2000) found that *vehicle travel reduction* it self should not be considered as only objective of traffic management. The improvements of *economic efficiency*, *safety*, *promoting cycle use*, *promote bus use* are also considered as objectives for traffic management. The achievements of these objectives also create significant side effect in reduction of vehicle travel demand. This study also concluded that indications of absolute travel demand reduction measure (traffic avoiding) are not significant in the case studies, but it should continue to be taken into account with more efforts in order to achieve success. Other recommendations were drawn as follows:

- Appropriate traffic management measures would then be packaged in order to achieve synergy effectiveness.
- A range of decision makers need to be involved from national, EU levels, as well as from the city and local communities, so that they are all supporting both strategic policy framework and complementary implementation packages.

- **Germany**

In comparison with the remarks of Dr. Keil in Köln's symposium 1971, the current situation indicates a very far progress of German cities in planning and application of traffic management measures (see Table 2-1).

In a study of over eighteen German metropolitan regions, Boltze, Krieslich et al. (2002) found that most of the investigated regions pursue an application level from middle to high in their traffic management projects, but only one-third have been at a high level of application. The majority of the regions (ten out of eighteen) are standing at a middle level of application at that time, in 2002. The main reasons for that difference between plan and achievement are financial problems, coordination between clients and contractors in transport and the significant changes in urban and transport structure. This study also recommended further research on traffic management in Germany, for example, quality management for traffic management measures, public transport and NMT measures.

Recently, traffic management projects in Germany are focusing on dynamic traffic management approach, which is a process of selecting dynamic traffic measures in formulating traffic management strategies in order to response to the actual traffic condition in the road and public transport network (FGSV, 2003).

Table 2-1: Application of traffic management measures in Germany until 2002

Contents		Investigated Region																	
		Bentheim-Ostwestfallen	Berlin	Bremen	Desden	Hamburg	Hannover	Karlsruhe	Köln	Leipzig	Margdeburd	München	Nürnberg	Postdam	Rhein-Main	Rhein-Neckar	Ruhrgebiet	Stuttgart	Ulm
1.	**Individual Motorised Vehicle Measures**																		
1.1.1	Federal Expressway Traffic Control		●	●		●	●	●	●	●		●	●	●	●		●	●	
1.1.2	Control at Expressway Exits to Lower Level Road Network			●			●										●		
1.1.3	Urban Traffic Control		●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	
1.1.4	Dynamic Parking Place Management			●					●		●	●	●	●		●			●
1.1.5	Entering Control for Urban Areas											●							
1.1.6	Road Pricing																	●	
1.1.7	Individual Route Guidance								●			●			●			●	
1.1.8	Carpooling and other Ride Sharing		●																
1.1.9	Travel Association																		
1.1.10	Fleet Management		●		●					●	●								
1.2.1	Static Information of Transport Infrastructure														●	●			
1.2.2	Dynamic Information of Traffic Situation		●		●	●	●		●		●	●	●	●	●			●	
1.3	General Strategies for IMV		●	●	●					●	●	●	●	●	●		●	●	
2	**Public Transport Measures**																		
2.1.1	Operation	●	●	●	●	●	●	●		●		●		●	●	●	●	●	●
2.1.2	Demand Oriented Operation	●			●				●			●	●						
2.1.3	Fare			●	●	●													
2.1.4	Collective and Individual Navigation for Passengers																	●	
2.2.1	Static Information		●	●		●	●	●	●						●	●			●
2.2.2	Dynamic Information for Operators		●	●	●	●	●		●		●			●	●	●		●	●
2.3	General Strategies for Public Transport			●				●		●		●			●				●
3	**Non-motorised vehicle Measures**																		
3.1.1	Dynamic and Individual Navigation																●		
3.2.1	Static & Dynamic Information										●					●			
3.3	General Strategies for NMV																		
4	**Intermodal Transport Measures**																		
4.1.1	Dynamic Trip chains			●	●							●				●		●	
4.1.2	Transport Hub for pPssenger Transport																		
4.2.1	Travel and Mobility Services	●	●		●			●	●			●			●		●	●	
4.3	General Strategies for Intermodal Transport	●	●	●	●		●	●	●	●			●	●	●		●	●	

[Source: translated from Boltze, Kieslich et al. (2002)]

2.2.3. Traffic Management Strategy Formulation

- **Formulation by Compatibility of Measures**

This method has been adopted by Remak and Rosenbloom (1976) as the first try to combine traffic management measures in packages. In this study, the compatibility of the measures was analysed in two stages. In the first stage, the measures were analysed by a pair-wise matrix in order to define their mutual compatibility at three levels: *Mutually supportive, Neutral and Conflicting pairs.*

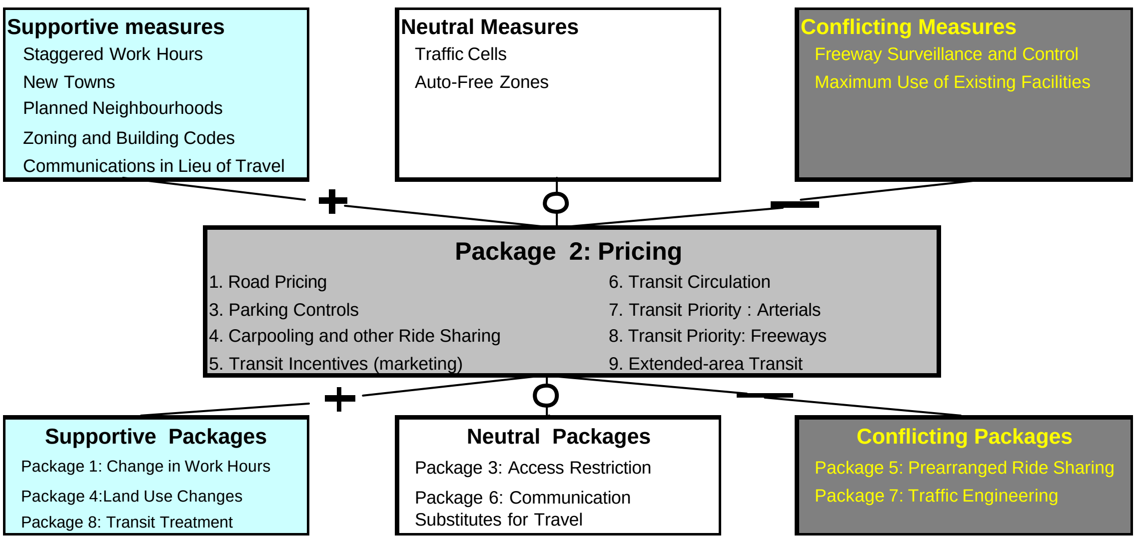
Basic Measure \ Supplementary Measure	Carpooling and other Ride Sharing	Zoning and Building Codes	Planned Neighbourhoods	New Towns	Communications in Lieu of Travel	Traffic Cells	Auto-Free Zones	Staggered Work Hours	Parking Controls	Road Pricing	Transit Circulation	Transit Priority : Arterials	Transit Priority : Freeways	Extended-area Transit	Transit Marketing	Maximum use of Existing facilities	Freeway Surveillance and Control
Road Pricing	+	o	o	o	+	+	o	+	+	+	+	+	+	+	+	-	-
Parking Controls	+	+	o	o	+	+	o	+	+	+	+	+	+	+	+	-	-
Staggered Work Hours	-	o	o	o	o	o	o	+	+	+	+	+	+	+	+	-	-
Auto-Free Zones	o	+	+	o	o	+	+	o	o	o	+	+	+	+	+	o	o
Traffic Cells	o	+	+	o	o	+	+	o	+	+	+	+	+	+	+	+	+
Maximum use of Existing facilities	-	+	+	o	-	+	o	-	-	-	-	-	-	-	-	+	+
Freeway Surveillance and Control	-	o	o	o	o	+	o	-	-	-	-	-	-	-	-	+	+
Zoning and Building Codes	o	+	+	+	o	+	+	o	+	o	o	o	o	o	o	+	o
Planned Neighbourhoods	o	+	+	+	o	+	+	o	o	o	+	o	o	o	o	+	o
New Towns	-	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	o
Communications in Lieu of Travel	-	o	o	+	+	o	o	o	+	+		-	-	-	-	-	o
Carpooling and other Ride Sharing	+	+	+	-	-	o	o	-	+	+	+	-	-	-	-	-	-
Transit Marketing	-	o	o	o	-	+	+	+	+	+	+	+	+	+	+	-	-
Transit Circulation	+	+	+	o	-	+	+	+	+	+	+	+	+	+	+	-	-
Transit Priority : Arterials	-	o	o	o	-	+	+	+	+	+	+	+	+	+	+	-	-
Transit Priority : Freeways	-	o	o	o	-	+	+	+	+	+	+	+	+	+	+	-	-
Extended-area Transit	-	o	o	o	-	+	+	+	+	+	+	+	+	+	+	-	-

Note: + = mutually spuportive. **-** = mutually conflicting. **O** = Neutral

[Source: Remak and Rosenbloom (1976)]

Figure 2-5: Combining eight packages of traffic management measures

In the second stage, the matrix was rearranged according to the relative compatibility of the pairs to suggest whole grouping of measures that could successfully be combined within a single program package (see the example in Figure 2-6).



[Source: adapted from Remak and Rosenbloom (1976)]

Figure 2-6: Schematic of package 2: Pricing

As explained by Remak and Rosenbloom (1976), three levels of compatibility can be understood as follows:

- *Mutually supportive pairs* range from (i) those the combined application of which yields a greater effect than the sum of the two implemented individually; to (ii) those of which one measure will fail to improve traffic situations unless it is accompanied by another complementary measure.
- *Conflicting pairs* may range from those that can yield somewhat less than the sum of their individual effectiveness when implemented simultaneously to those that can render each other ineffective or even a further traffic problem.
- *Neutral pairs* include measures that have no positive of negative synergy effect when they are simultaneously implemented.

The report also recommended application areas of the defined packages according to its definition of five type common peak-period congestion problems. Finally, the analysis of compatibility between packages was also conducted by the pair-wise matrix analysis.

- **Formulation by Potential Benefits of Integration**

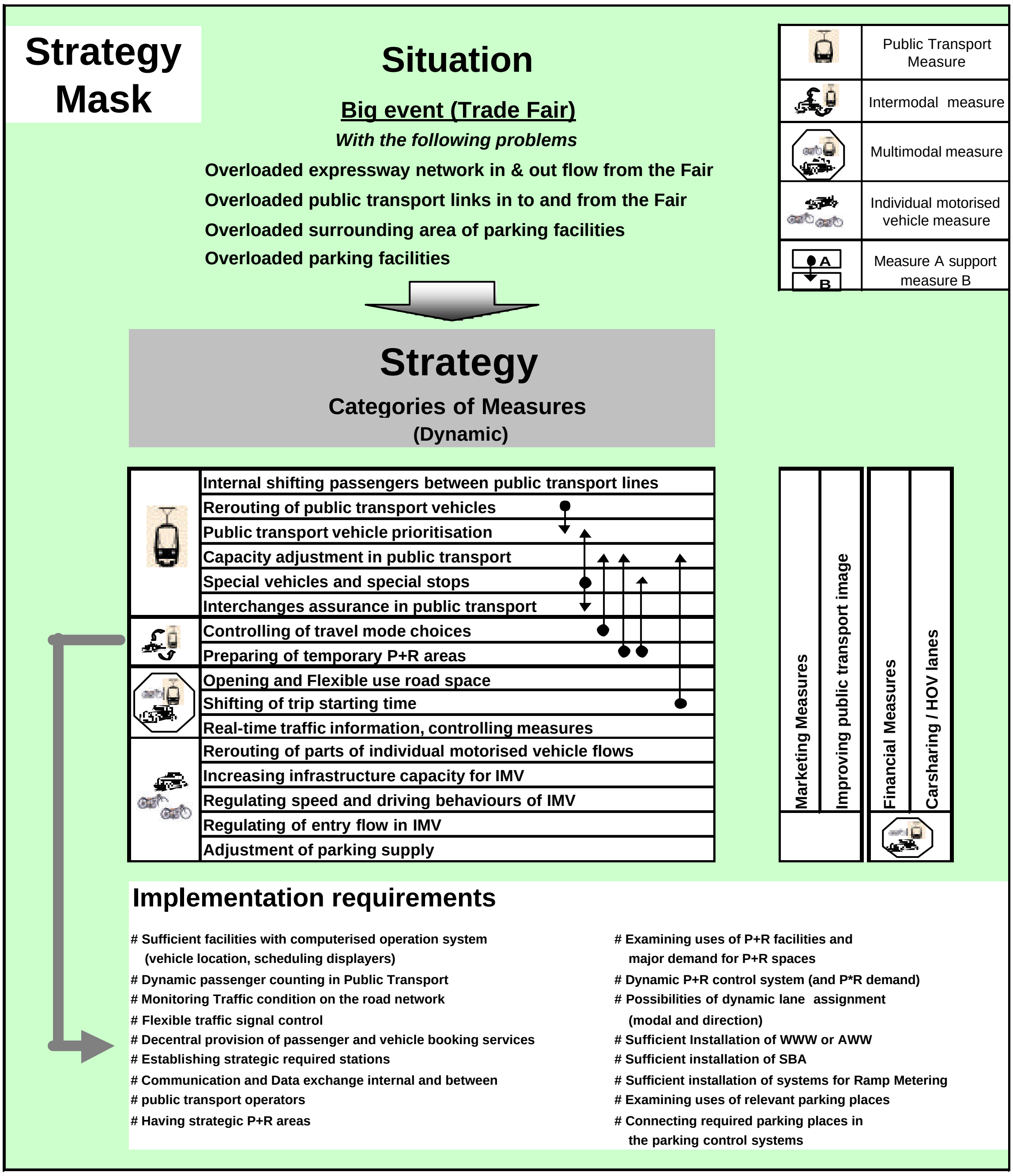
This approach has been adopted by May and Roberts (1995) as the key argument for designing of integrated transport strategies in general. Using the pair-wise matrix analysis, the authors divided the *compatibility* (see above section) into three potential benefits of combination transport measures into packages, including *complementary,* financial *support, and public acceptance support*. However, the authors did not mention the conflicting or neutral interactions between measures. Furthermore, May and Roberts (1995) concluded that the priority in formulating an urban transport strategy should be given to the following three types of measures: (I) Measures, which need to be implemented to facilitate the others; (ii) Measures, which generate income for financing the others; (iii) Measures which improve public attractiveness for the others.

Recently, May, Kelly et al. (2006) replaced the three benefits of integration by two types of principle: (i) the pursuit of *synergy* and (ii) the removal of *barriers*. The authors defined the term "synergy" to describe the effects of positive interactions between measures and it was divided into four levels from (1) synergy, to (2) additivity, (3) complementary, and (4) perfect substitutability. The "barrier" is used to indicate the obstacle, which prevents a certain measure being implemented, or limits the way in which it can be implemented. Four types of barriers have been mentioned as (i) legal and institutional barriers, (ii) financial barriers, (iii) political and cultural barriers, and (iv) practical and technological barriers. Although the principle of integration has been comprehensively established, the experimental case studies have examined only few examples of synergy effects between measures. The authors also recommended that more research is needed to investigate the concept of integration.

- **Traffic Management Strategy Mask**

As the concluding remarks of this sub-chapter, traffic strategy masks should be introduced as the final products of a team, which was employed to carry out the traffic management study. Recently, German experts presented traffic management strategy masks, which include not only traffic management measures, but also the basic requirements for implementation of those measures (Andree, Boltze et al., 2001; FGSV, 2003). The Guidelines on Developing of

Strategies for Dynamic Traffic Management defined nine strategy masks as corresponding solutions for nine urban transport situations (FGSV, 2003).



[Source: (FGSV, 2003)]

Figure 2-7: Example of general strategy mask for a big event

Although the complementary impacts between measures are presented in the strategies masks (see Figure 2-7), the guidelines do not explain the principles and criteria for the integration of traffic management measures in formulating strategies. Therefore, in formulating traffic management strategies for motorcycle dependent cities, the approach of May and Roberts (1995) and the late version of May, Kelly et al. (2006) can be recommended, but with consideration also for the conflicting and neutral interactions between measures.

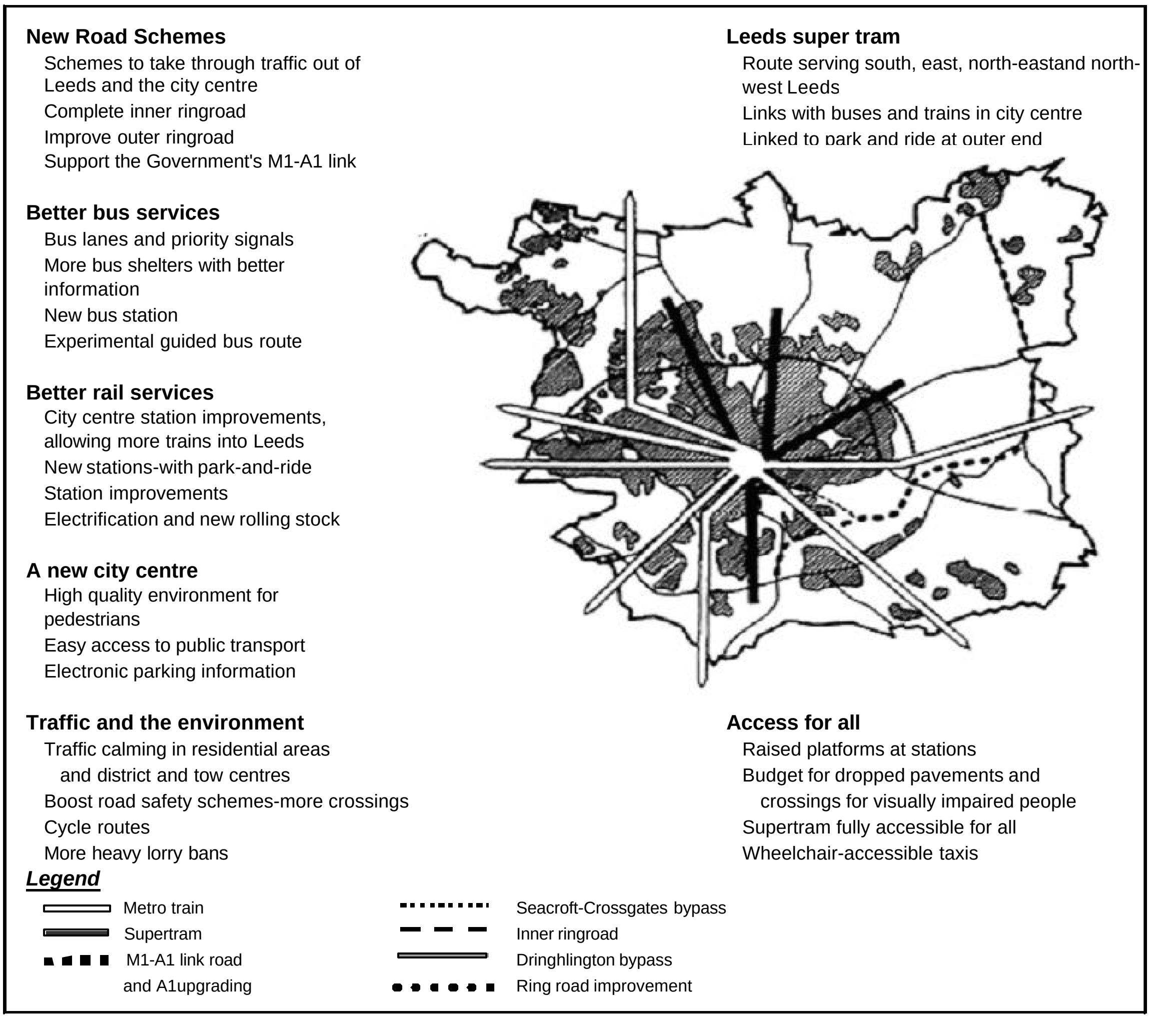
2.3. Traffic Management Planning

This sub-chapter studies the current state of integration traffic management in transport planning process. Section 2.3.1 draws a picture about the integrated traffic management in the existing transport plans. Section 2.3.2 discusses different approaches in planning traffic management activities in a separate traffic management program or plan. In the last paragraphs, discussions emphasise on Traffic Management Plan, which is on the way of development based on long time practical experiences of urban and regional scale traffic management projects in Germany. Finally, section 2.3.3 reviews current approaches in assessing traffic management measures and strategies.

2.3.1. Integrated Traffic Management Package in the Existing Transport Plans

- **General Situation**

Conventionally, traffic management measures are considered as low cost alternatives to the infrastructures in different planning areas and objectives (IHT, 1996). The integrated approach utilises traffic management measures as short-term solutions during the preparation, construction, and operation phases of the infrastructures and public transport.



[Source: O'Flaherty (1997.a)]

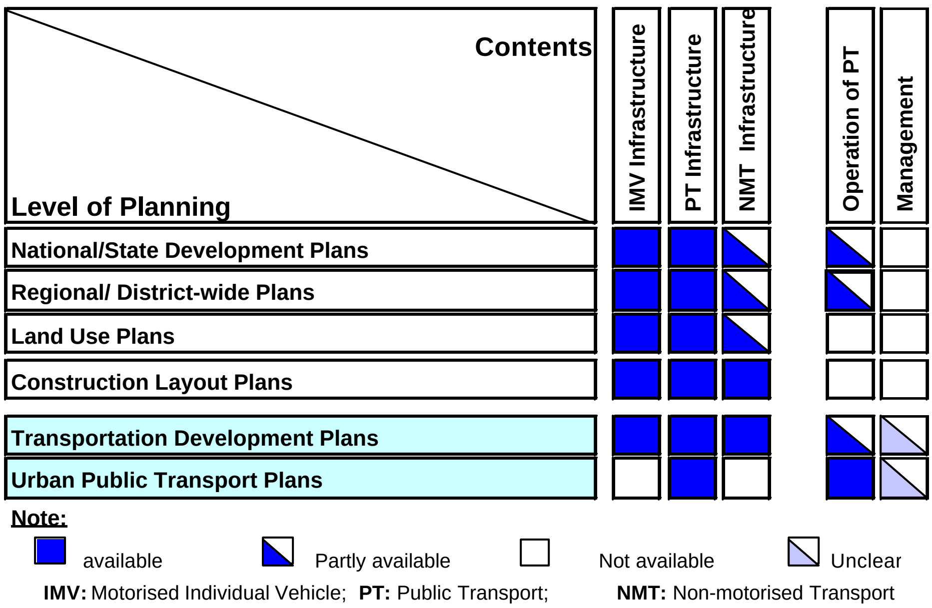
Figure 2-8: An example of integrated transport plan in the City of Leeds

Therefore, the final projects' plans include both new facilities and solutions to optimise the performance of the existing system. On a wider scale, this integrated planning approach is also recommended for regional transport development plans (DfT-UK, 2004).

As stated by May and Roberts (1995), "**an integrated approach, in which infrastructure provision, management of existing infrastructure, and pricing of use of that infrastructure are coordinated, can significantly reduce the scale of urban transport problems**". The main problem of this approach is that the inertia of conventional way of thinking, practical experiences and standards will lead the plans to focus mainly on the infrastructure development objectives, and the traffic management part is normally forgotten or overlooked. Therefore, this approach may be applicable in developed cities, where major infrastructure and public transport services are already available, but may not be easily applied in developing cities. Moreover, no publication draws a comprehensive analysis about the state of integration of traffic management into urban and transport development plans, including land use plans.

- **Experiences in Germany**

Bohlinger (2006) found that in the existing development plans (national/state, regional, urban scales), there is little consideration on traffic management.



[Source: translated from Bohlinger (2006)]

Figure 2-9: Traffic management in planning process – German experiences

The situation is not so different in the professional plans in transport, where traffic management measures are only selected qualitatively, and their impacts were completely neglected. The analyses indicate differences between German and British situation, especially in the contents of transport development plan. The differences indicate two approaches in promoting traffic management in urban transport. The UK approach emphasises more on integrated transport plans, where the German one focuses on developing a concept of Traffic Management Plan as a separate type of plan in the transport planning process (see Figure 2-11).

- **Experiences in Developing Countries**

In the Master Plan of Urban Transport for Hanoi City, an attached Traffic Management Plan (TMP) was proposed as a sub-plan, which was presented in a package of thirty-eight traffic management measures (JICA and HAPC, 1997). However, this package was absent from the priority list of recommended projects. Furthermore, there was no assessment of impacts of the traffic management measures. The interaction between traffic management measures and the infrastructure projects were neglected totally. No indication of any financial resource can be recognised as allocating for the implementation of such management measures.

In the Study on Urban Transport Master Plan in Hochiminh City metropolitan area, traffic management was proposed as one of seven master plan work-packages. The traffic management package combined five strategies: (1) establishment of comprehensive management system for motorised vehicles, (2) strengthening of traffic regulation and management, (3) effective response to freight transport, (4) establishment of parking policy, and (5) introduction of travel demand management. The total cost of traffic management in the period 2000-2020 was calculated about US$ 150 millions, accounted for 1.1% total cost of the HOUTRANS (JICA, MOT et al., 2004). Unfortunately, no analysis indicated the impacts of traffic management strategies on the planned transport system.

2.3.2. Traffic Management Plan

This section presents an overview of the development of the Traffic Management Plan in three international pioneers of traffic management. The USA is discussed first in the respect of their leading position in many aspects of transport. The United Kingdom is also well-known as the first case of city scale road pricing in Europe. Finally, the study looks at the situation in Germany, where the term "traffic calming" was initiated.

- **The United States of America**

In the US, traffic management activities are usually implemented as reactive traffic management programs in response to local traffic problems, for example, carpooling programs, public transport subsidy programs for employees or car-sharing programs etc. The planning efforts focus on combining traffic management measures into packages in order to utilise the synergy effects between measures in the small-scale projects.

In the first comprehensive investigation on application of traffic management measures in the US, Remak and Rosenbloom (1976) drew some remarks about the need of packaging traffic management measures as:

- None of the individual techniques studied demonstrates a potential for significant reduction of traffic congestion.
- Joint implementation of compatible techniques can be significantly more effective in reducing peak period traffic congestion.
- Different types of congestion require different solutions, and no simple program can be expected to provide an equally effective solution to all types of congestion.
- Many options are available for designing packages of compatible techniques.

Later, ITE, Georgia IT et al. (1993) recommended that traffic management programs should be developed within the framework of overall planning process for an area and they should follow a five-steps planning process as follows:

- Determine the true nature and severity of your problem.
- Assess where current transport program plans are likely lead you in resolving these problems and identify shortfalls where traffic management strategies could be appropriate.
- Using information, explore a range of traffic management options available to you and assess the impact they will have on your transport problem, with little concern at this point whether they are implementable.
- Study the trade-offs among the different alternative approaches regarding cost, timing, impact and other criteria important to local condition decision makers. Decide which measures would be most effective to implement.
- Decide what mechanisms you will need to implement your chosen program.

However, that planning process was established from the viewpoint of private business (employer) with the designated users as employees other than a common concept, which could cover the benefits of different types of users and non-users in an urban area.

Recently, Meyer and Miller (2001) emphasised that traffic management should be considered as an alternative to road infrastructure or public transport development. However, these authors also recommended traffic management measures should be integrated into transport development plans.

- **The United Kingdom**

Theoretically, transport experts and authorities in the United Kingdom prefer the approach of applying traffic management measures as an integrated part of an integrated urban transport plan (May and Roberts, 1995). However, in many cities in the UK, the extensive and older approach in promoting traffic management is still applied as an alternative to road infrastructure or public transport service within the framework of an urban transport development plan. O'Flaherty (1997.a) recommended five main options in transport planning, including (I) do-minimum, (ii) land use planning measures, (iii) car-oriented transport network, (iv) transit-oriented transport network, and (v) travel demand management. This approach was repeated by May, Shepherd et al (2000) when searching for optimal integrated transport strategies for European cities. The recommendations of this study show that traffic management is a complete alternative of infrastructure development. Among infrastructure measures, only small-scale road modifications are recommended.

- **Germany**

The German approach in promoting traffic management develops in a more technical way, which is different from the other two pioneers. In this approach, the concept of an independent ***Traffic Management Plan*** (TMP) has been initiated for almost twenty years by many regional and city scale traffic management projects (Schnabel, 1997; Boltze, Kieslich et al., 2002). However, a complete concept of TMP is still in the phase of research.

Project	City/ Region	Measures /Techniques 1	2	3	4	5	6	7	8
STORM	Stuttgart	○	○	●	●		●	○	●
VIKTORIA	Köln		○		●				●
LIAISON	Berlin		●	●	○	●	○	●	
COMFORT	München	○	●	○	●	●		○	●
RHAPIT	Rhein/Main	●	●	●	●	○	○	○	●
ASTRA	Bochum	●	○						
MELYSSA	Stuttgart		○	○				○	●
BEVEI/ACCEPT	Rheinkorridor	●	●						
CITRA	München		○	○			○	●	●
CORE/EURO-TRIANGLE	Rhein/Ruhr		●						●
DESPINA	Stuttgart	●	●						
FRUIT	Frankfurt	○	○	○	○	○		○	●

Legend: ● Project focus point ○ Project Level Aspect

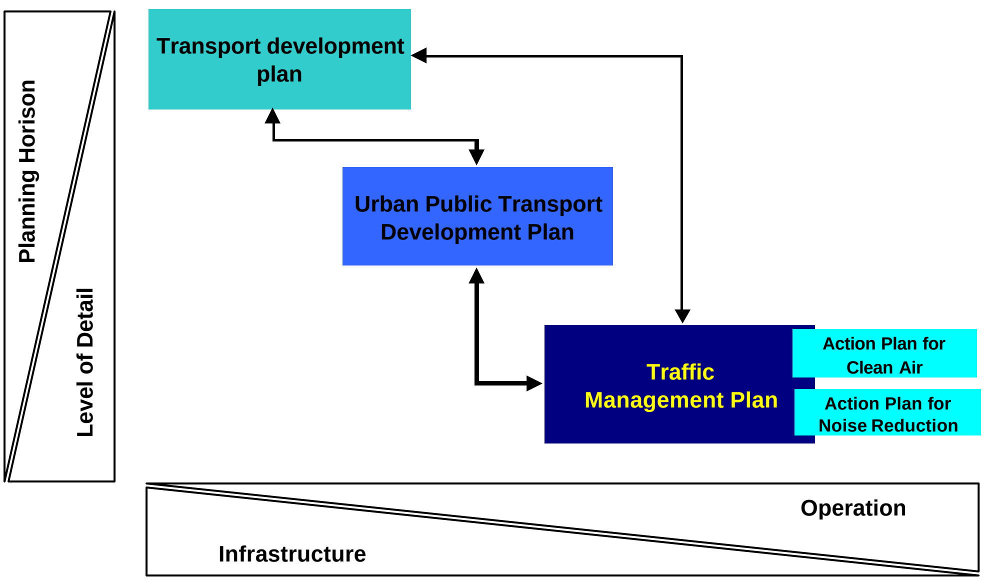
Form of Data communication
RDS/TMC: STORM, COMFORT, MELYSSSA, CITRA, BEIVEI
Beacon: STORM, COMFORT, MELYSSSA, CITRA, LIAISON
Mobile radio: RHAPIT

1= Pretravel Information **2= Ontravel Information**
3= Destination Guidance **4= Park and Ride**
5= Urban Public Transport Prioritisation **6= Emmergency Calling System**
7= Fleet Management **8= Integrated Traffic Management**

[Source: translated from Schnabel (1997)]

Figure 2-10: Some regional and urban traffic management projects in Germany

Recently, for the first time, Bohlinger (2006) presented a concept Traffic Management Plan that was expected to apply to all levels of urban transport planning (Level 1: intermodal and multimodal network, Level 2: Coordination of single mode network, Level 3: Single facility or service) of urban transport planning system (see more detail in Vuchic, 1999). Figure 2-11 presents the position of the TMP as a short-term and detail plan in the urban transport planning system. It executes the general traffic management objectives in the long-term plans and corrects the errors of long-term forecasting.



[Source: Translated from Bohlinger (2006)]

Figure 2-11: Traffic management plan in the transport planning system

Furthermore, the researcher mentioned the need to have a regional TMP, which could coordinate the TMPs of different cities and communities within the region. Although the study is no yet complete, some parts of theoretical findings have been presented in unpublished reports, professional seminars, and conferences. Functions, planning process and requirements of Traffic Management Plans are presented in the followings.

Functions of Traffic Management Plans

Bohlinger (2006) addressed the functions of the Traffic Management Plans as follows:

- to strengthen the applications of traffic management,
- to improve the coordination inside and between communities, major traffic generators, and the region via a systematic approach,
- to strengthen the goal-oriented approach via the coordination and concretion of goals and objectives in traffic management and other urban and transport plans,
- to improve the efficient of financial resources via the pre-defined, area-wide, adjusted and goal-oriented options of priority situations and proper strategies.

Traffic Management Planning Process

According to Bohlinger (2006), a TMP should follow the same five-step procedure of the general transport planning process (FGSV, 2001), including Orientation, Problem Analysis, Searching for Solutions, Consideration and Decision, and Implementation and Monitoring Effects (see more detail in the Annex A-3).

Requirements of the Traffic Management Plans

As a planning instrument, a Traffic Management Plan should fulfil the following requirements (Bohlinger, 2006):

- Ability of integration in the transport planning process and compatibility with the existing plans,
- Planning efficiency by utilising available data, information, and understanding about the local conditions,
- Possibility of having modular, flexible and step-wise designs (form, affected area, contents, precision) in corresponding with conditions of different planning areas,
- Possibility of having short-term and least-cost solutions (specification, adaptation, and changes),
- Determination of the connections and interactions between Traffic Management Plans as well as clarification of responsibilities and participation forms.

Although further efforts are still needed to fulfil the scientific question on Traffic Management Plan, from the above analyses one can come up with awareness about the relevance for the German Traffic Management Plan Concept in Motorcycle Dependent Cities. The short-term horizon of the TMP is suitable to carry out in the cities, which grow at the rate of 10 to 15% per year. The other advantage of the short-term TMP is the quantity of data that can be significantly reduced in comparison with the conventional long-term transport development plans. Short-term projection range does not require sophisticated planning tools, which are usually too expensive and absent in developing countries. The other advantages of TM are low cost of study, flexibility, and modularity.

2.3.3. Assessment and Evaluation of Measures and Strategies

- **General Requirements of Assessment and Evaluation**

According to FGSV (2001) assessment and evaluation of measures aim to answer two basic root questions:

- What are the impacts of proposed traffic management measures? Moreover, how much are the scale and intensity of the impacts?
- What are the most suitable measures for solving problems in the targeted area?

In principle, impact assessment and evaluation are two consequent steps. The assessment provides fundamental information about the nature of interactions between internal process of measures and their external environment (transport system and urban activities) (FGSV, 2001; Papacostas and Prevendouros, 2002). Evaluation screens the impacts under considerations of legal, technical, financial, institutional, and public acceptance conditions of measures in order to provide overall comparisons between measures. Results of the comparisons will be the basic knowledge for decision makers to decide. This mentioned principle can be applied to different types of study, and the questions can be answered at different levels dependent on the nature of studies.

Estimated information is the nature of outcomes from assessment and evaluation for planning phases (before a full scale implementation), while *revealed information* is the outcome of monitoring and control during implementation.

- **Assessment Models and Criteria**

In their study, Remak and Rosenbloom (1976) employed a model with two groups of assessment criteria, which are *benefit* and *feasibility* (see Table 2-2).

First, the criteria and sub-criteria of benefits and feasibility were applied to conduct a qualitative assessment of measures, which were implemented and proposed in the USA until 1975. The application areas were identified as the nature conditions to assess the effectiveness of measures other than as criteria for assessment. Five application areas are recommended for implementing measures: Central Business Districts (CBDs) of large cities, CBDs of small cities and suburban activity centres, Urban expressway and Arterials, Roadway with strong imbalance traffic during peak hours, and Roadway for which options in alternative routes are limited. Outcomes of this assessment consisted of both estimated information (related to the proposed measures) and the revealed information (relate to the applied measures).

Secondly, the criteria were employed to assess the packages of measures. The benefit criteria are rearranged into a new group, called cost and effectiveness. The feasibility criteria remain and two other new criteria groups are invited, *compatibility between packages* and *applicability in relations with the applied areas*. Outcomes of this assessment are purely estimated information, which predict the impacts and feasibility of the packages.

Table 2-2: Assessment criteria for congestion-reduction measures

Groups	Criteria	Sub-criteria
Benefits	Effectiveness	Reduction of congestion in applied areas
	Cost of implementation	Basic cost for provision of measure
		Secondary cost for additional facilities
	Indirect benefits and dis-benefits	*Diverse traffic congestion*
		Long-rang travel demand and patterns
		Energy consumption
		Environmental pollution
		Public safety
		Economic impacts
		Equity considerations
		Institutional Considerations. Public
		Institutional Considerations. Private
	Time factors	*Preparation duration*
		Benefit duration
Feasibility	Institutional support	*At project level institutions*
		Higher level Institutions
	Public acceptance	*Public approval (political bodies)*
		Public participation (people)
	Private sectors acceptance	*Transport operators*
		Other businesses
	Legal compatibility	*Project level laws and regulations*
		Higher level laws and regulations
	Technological readiness	*Required control systems*
		Information technology infrastructure

Note: *Criteria and Sub-criteria in Italics are redefined based on authors' descriptions*

[Source: adapted from Remak and Rosenbloom (1976)]

Finally, a rating system was employed to compare the packages in the aspect of *direct cost* and *effectiveness*, *indirect benefits* and *dis-benefits*, *time* and *feasibility*. The ratings were qualitatively given based on descriptive analysis of impacts of packages, except the estimation values of costs,

Marshall, Banister et al. (1997) introduced a strategic assessment model. This model examined the suitability of different global contributing factors on travel reduction strategies and measures. Secondly, it assessed measures on their natural impacts on traffic. In the first step, the authors found that five global factors, including *technological changes*, *infrastructure provision*, *and changes in urban form*, *freight practices*, and *cost of transport*, were suitable for travel reduction strategies, while other three, *demographic changes*, *economic changes*, and *political changes,* were not suitable. In the second step, the authors assessed the impacts of measures by two groups of criteria: *switching* (as the same meaning with shifting) and *substitution* (as the same meaning with avoiding). The switching impacts were classified by *mode*, *destination,* and *time*. The substitutions were made by *linking of trips*, *information technology*, and *modification of trip forms*. In that study, the assessment was very simple. The outcome was only a crossing matrix for indicating which impact was identified from which measure. In the later study, Marshall and Banister (2000) employed the same criteria and crossing matrix, but the impact was qualitatively rated as *significant influence* or *some influence.*

Sakano, Benjamin et al. (2001) conducted a national wide web-based questionnaire study on seventy-two Metropolitan Planning Organisations in the USA. Nine traffic management measures had been assessed by four groups of criteria, including *public acceptance*, *equity effects*, *effectiveness* and *costs.* Effectiveness were assessed in reductions of *congestion*, *travel time* and *air pollution*. Costs were considered in *implementation*, *operation* and *non-monetary*. At the end, a cost-effective evaluation was conducted. In selecting assessment criteria, this study drew some useful remarks as follows:

- The assessment criteria of this study can be applied for further quantitative assessments.
- Descriptive analysis is useful and necessary to identify and recommend traffic management measures for specific application projects.
- Descriptive analysis is an essential complement to regression analyses, which are normally applied to compare different traffic management alternatives.

Recently, Bohlinger (2006) adopted a very comprehensive four-step assessment model that can be described as follows:

- Step 1: Assessment of measures on suitability with goal and objectives of Traffic Management Plan,
- Step 2: Applicability assessment,
- Step 3: Checklist assessment of measures in applicability, effectiveness, cost, impacts, Robustness, and Flexibility,
- Step 4: Quantitative estimation and appraisal of impacts.

This model is expected to be applied to Traffic Management Planning projects, where the required data, planning tools, skills, and resources are available. However, this model has not been applied in the real world.

2.4. Requirements for Traffic Management

2.4.1. Laws and Regulations

Normally, there are laws and regulations on planning, construction, and operation of transport infrastructures and services. In most of the cases, traffic management measures have been implemented under current legal umbrella. In some cases, adjustments of legal conditions may be required to implement certain measures (e.g. Vehicle tax, road pricing). The adjustment can be achieved easily if it is limited to provide or modify some technical guidelines. The adjustment will need a complex process to achieve if it challenges the current laws, regulations and standards, especially at the national and regional level. The levels of difficulty of adjustments differ from one country to another.

2.4.2. Technical Resources

Data availability

Bohlinger (2006) addressed the most important technical requirement of traffic management which is the availability of data. The availability of data depends on the methods, tools, mechanism, and media of collection, analysis, storage, and provision. Level of data requirement in terms of quantity and quality depends largely on the level of planning (e.g.

master plan, modal plan or project plan), the characteristics of measures (e.g. static or dynamic application), the planning methods and tools, and the decision-making mechanism.

Availability of Planning Tools

The provision of computerised planning tools is also very important for Traffic Management Planning process. The various causes and consequences of transport problems, the multi-disciplinary design and multi-sectors impacts of a transport solution today, limitation of human brain capability, time, and resources require the support of that computerised planning tools. One of the most critical problems for TMP in the MDCs is the lack of planning tools that are developed for motorcycle dominated traffic flow and/or other local traffic conditions.

Availability of Skills

The human resources are needed in all phases of TMP process. According to ITE, Georgia IT et al. (1993), the personnel should have the following skills: (i) understandings of the nature of local conditions and problems, (ii) awareness of the traffic management measures and their applicability, (iii) technical tools, information and training to properly evaluate the effectiveness of different options, and (iv) sufficient knowledge of managing the process of traffic management.

Availability of Technical Systems

The availability of related technical systems is important in selecting and implementing traffic management measures. The provision of computerised pubic transport operation system is essential for implementing of dynamic traffic management measures, for example, dynamic public transport scheduling or real-time information services. An automatic traffic monitoring system is necessary for dynamic traffic control measures.

2.4.3. Financial Resource

The key advantage of traffic management is low-cost in comparison with the new supply capacity provision. In fact, many traffic management measures need only fund for the initiative step, after that they will be self-financed or even become financial sources for other measures (e.g. road pricing). However, a sufficient finance or initiation and maintaining the planned management impacts is critical to realize the activities and to achieve the goals and objectives. The initiated capital cost of Singapore Area Licensing System (ALS) was S$6.6 millions in 1975 and the revised version in 1989 cost S$ 17 million (Phang and Toh, 2004).

2.4.4. Institutional Requirements

Organisational Concept

According to the scale of impacts and the related stakeholders, an organisational concept is needed before any concerted effort in study and implementation can be undertaken. The organisational concept will be simple if only a company wants to provide incentives to encourage its employees to commute by transit service instead of driving a car. The organisational concept will be much more complex if a city or regional government wants to develop a Traffic Management Plan for a medium horizon.

Participation of Related Institutions

Remak and Rosebloom (1979) found that the commitments and coordination between related government institutions are the key to success. Conventionally, traffic control activities involve mainly two groups: transport authorities (engineering works), and traffic police (enforcement). Today, traffic management activities, in a city, for example, involves a large number of public, private institutions, which are not only at the city level, but also at the regional and national levels. According to Marshall, Banister et al. (1997), in European countries, local government, national government, employers and transport companies are the most frequent responsible institutions for implementation of traffic management .

2.4.5. Public Acceptance

In a typical democratic society, public acceptance should be considered as backgrounds for any institutional action. The public acceptance is firstly addressed through the law-making bodies, which influence the initiation and realisation of traffic management measures or programs, by laws and regulations. Secondly, it is the participation of people during the implementation phase of the measure. In developing countries, awareness and practice of democratic power exist among a minor group of elite people only. The rest of people do not have enough capability to participate in the democratic process of decision-making. Therefore, different models, and different approaches in acquiring public involvement in public impacted decisions should be carefully examined for developing countries.

2.5. Conclusions

This chapter reviews the available literature on five fundamental aspects of traffic management: key definitions, measures, strategies, planning of traffic management activities, and requirements for application of traffic management.

- **Key Definitions**

The key definitions began with a modal definition of *transport system* that consists of objects and subjects of traffic management activities. The term *traffic management* is selected from different terminologies to define the efforts to balance demand and supply in transport by the measures. The traffic management measures are defined and classified by transport modes and characteristics. The traffic management strategy is also defined from a general perspective, on a spatial scale, and in nature of traffic impacts as well. Traffic Management Plan is a new approach that adopts a new type of plan, which is proposed to fulfil the gap between long-term transport development plans and daily traffic management activities.

- **Traffic Manageme nt Measures and Strategies**

In the past, traffic management was limited only to the area of traffic control and regulation of road traffic. Since 1970, traffic management has been extended into different areas and has integrated different disciplinary into its concept (Kreil, 1973). Today, traffic management includes a wide range of measures, from the original traffic engineering to economical, administrative and organisational and information measures.

Application of Traffic Management Measures

In general, traffic management measures have been applied widely in developed countries, especially in European countries, where the traffic management has been significantly contributed to the success of many liveable cities. However, the review based-on a study in 1997 shows that the level of application was still below the medium level in most of the investigated countries, except Germany. In this country, the majority of the regions had a middle or high level of application at that time. Therefore, a German experience and approach in promoting traffic management should be examined closely.

Formulation of Traffic Management Strategies

Remak and Rosenbloom (1976) adopted the *compatibility* analysis in formulating packages of traffic management measures. They presented a pair-wise matrix in which pairs of measures are defined as mutually supportive, conflicting, or neutral. This approach was also employed by May and Roberts (1995), who interpreted the term *mutually supportive* into three lower criteria: *complementary, financial supportive and public acceptance supportive*. It was modified later by May, Kelly et al. (2006), who proposed two types of principle to integrate measures: *the pursuit of synergy* and *the removal of barriers*. The strategy mask was adopted by FGSV (2003) presenting transport situation, traffic management measures, relationships between the measures and requirements for implementing these measures.

- **Planning of Traffic Management Measures Activities**

Traffic Management Package in Transport Development Plans

This approach normally provides a very comprehensive plan, which covers all aspects of transport, including infrastructure, public transport, and management. This approach has been applied in many developed cities, but not well practiced in Germany (Bohlinger, 2006). The main issue is that the planners, decision makers, and implementers normally focused on infrastructure projects, traffic management objectives are often ignored or thrown out from the priority lists. The examples in Vietnam indicated that traffic management was considered during planning process, but finally excluded from the list of recommended projects.

Traffic Management Plan

For the concept of an independent Traffic Management Plan, the review presents an overview of the progress in the USA, the UK and Germany. In the USA, the travel reduction programs are recommended to apply a five-step planning process, which was introduced later by the Institute of Transport Engineers. In the United Kingdom, traffic management was strongly recommended to integrate into transport development plans, but in practice, traffic management is considered as a complete alternative to infrastructure and heavy public transport. In Germany, the reviewed literature presents a number of urban and regional scale projects, in which solutions were searched and found only among traffic management measures. This situation provides practical foundations for the study to develop the theoretical concept of a Traffic Management Plan in the urban transport planning system (Bohlinger, 2006). Although efforts are needed to complete the concept of Traffic Management Plan, this approach will be a future way for promoting traffic management.

Assessment of Traffic management Measures and Strategies

The study on current literature found that the current approaches in assessing traffic management measures wildly apply multi-criteria assessment models, which allows assessing both quantitative and qualitative criteria simultaneously. Most of the models are phased into two steps to answer two basic root questions:

- What will be impacts of proposed traffic management measures? Moreover, how much are the scale and intensity of the impacts? (*Estimation of impacts*).
- What are the most suitable measures to solve problems of the targeted area? (*Evaluation of measures*).

The criteria to assess the measures are normally categorised into two groups:

- *Effectiveness* of measure including improvements of safety, mobility, economic efficiency, and environment.
- *Applicability* of measure, including the difficulty to acquire costs, technical systems, institutional participation and public acceptance.

In the general studies, qualitative assessment is widely applied in order to give recommendations on applicable measures or strategies for further specific studies. The evaluation of the measures is usually conducted by rating methods.

- **Requirements for Traffic Management**

Planning and implementation of traffic management activities require a set of basic conditions, including laws and regulations, technical resources, finance, institutional participation, and public acceptance.

- **Remarks of Limitation**

Finally, statements of limitation of this literature review should be clearly presented:

- First, one may have questions about the lack of information about traffic management application in Asian cities. Reasons are many, but the main consideration is that experiences of traffic management in Asian cities are unique by cases.
- The second question may be asked for absence of review on traffic management in motorcycle dependent cities. So, the answer is presented in the next chapter together within the framework of urban transport problem analysis for MDCs.
- One may ask question on the lack of discussion about computerising tools for estimation of impacts and evaluation of measures and strategies. The reasons are many, but the first one can be accounted is that the characteristics of this study employs a general top down approach in finding possible solutions for different MDCs. The second reason is that the available computerised tools are either focused on car-based urban road traffic or deeply focused on specific transit system. One needs further studies to select proper planning tools for traffic management in MDCs.

3. Urban Transport Problem Analysis in MDCs

This chapter focuses on manifested transport problems in MDCS and their causes. In section 3.1, the definition of motorcycle dependence is formulated, for the first time, by three main criteria vehicle ownership, availability of alternatives to individual motorised vehicles, and motorcycle use. The following statements of deficiencies and problems are addressed in section 3.2. Section 3.3 focuses on analysing urban transport conditions that indicate the internal causes of problems. Urban development conditions are analysed in section 3.5 as examining the external causes of problems. The analyses here are conducted based on the data of the case study, Hanoi, and other five Asian cities. Some data from other cities are also referred to for comparison in some indicators in order to emphasize the uniqueness of the motorcycle dependent situation.

3.1. Defining Motorcycle Dependence

3.1.1. Overview

The term “motorcycle city” was adopted firstly by Barter (1999) to define the urban transport and land use situation of Surabaya in Indonesia and somehow in Hochiminh City, but the term was used without the corresponding indicators, except some discussions on motorcycle ownership. The following sub-sections focus on defining the term “*motorcycle dependence*” as a specific transport situation of a city by three groups of indicators: (i) vehicle ownership, (ii) availability of alternatives to individual motorised vehicles (IMV), and (iii) motorcycle use.

(a) Mix- and Motorcycle dominated traffic in Ludhiana, India (Tribune News Service, 2003)

(b) Regulated Motorcycle traffic in Taipei, Taiwan (Hsu, Shadullah et al., 2003)

Figure 3-1: Examples of motorcycle traffic flow

3.1.2. Selection Indicators

Recently, experts use a group of seven indicators in order to present the car dependence, including vehicle ownership, personal mileage, vehicle trips, quality of transport alternatives, relative mobility of non-drivers, and market distortions favouring automobile use (Online TDM Encyclopaedia, 2004). In this study, the indicators are applied to define the motorcycle dependence with several modifications. Firstly, lack of comparable data does not allow taking the average personal mileage, mobility of non-drivers, and market distortions. Secondly, the quality of alternative transport modes depends much on personal feelings, which differ from person to person. Therefore, this indicator is replaced by the availability of transport alternatives. Lack of data about non-motorised transport (NMT) does not allow to indicate its quantitative availability in this study, but the qualitative assessment is still conducted. The number of buses is selected as the representative indicator for quantitative availability of transport alternatives. Thirdly, the share of motorcycle in the traffic flow will be added as an indicator to emphasize the motorcycle dependence of the cities.

Therefore, the motorcycle dependence is defined by three groups of indicators: *vehicle ownership, availability of alternative, and use of motorcycle.* The rating system (high, medium, low) is also defined to classify the situation reflected by the indicators.

Table 3-1: Indicators of the motorcycle dependence

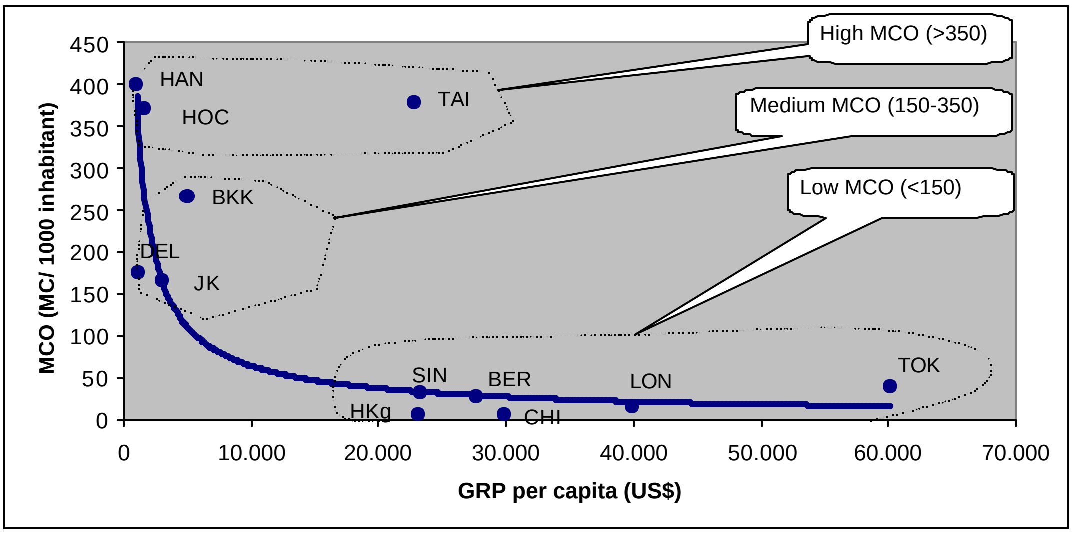
Indicators			Level					
			Low		Medium		High	
Main criteria	**Sub-criteria**	**Measurements**	***Value***	***Grade point***	***Value***	***Grade point***	***Value***	***Grade point***
Vehicle ownership	Motorcycle ownership (MCO)	MCs/1000 inhabitants	< 150	1	150-350	2	> 350	3
	Private car ownership (PCO)	PCs/1000 inhabitants	< 150	3	150-350	2	> 350	1
Availability of Alternatives to motorcycle and car	Bus transport availability (BO)	Buses/ 1000 inhabitants	< 1	3	1- 2	2	> 2	1
	Bicycle availability (BIO)	Bicycles / 1000 inhabitants	<150	1	150-350	2	>350	3
Use of Motorcycle	Motorcycle share in the traffic flow	% of MCs in the traffic flow (in vehicle unit)	<30%	1	30 - 50%	2	> 50%	3
	Modal split of Motorcycle	% of trips by MC	<20%	1	20 -40%	2	> 40%	3
	Modal split of Public Transport	% of Trips by Public transport	< 20%	3	20-40%	2	> 40%	1
	Modal split of Private Car	% of trips by cars	< 20%	3	20- 40%	2	> 40%	1
	Modal split of NMT	% of trips by NMT	< 20%	3	20 - 40%	2	> 40%	1

A rating system is established in corresponding with level of the indicators (see Table 3-1). For example, low motorcycle ownership will get 1 point and the high rate will get 3 points. In contrast, the low bus ownership will get 3 points. The rate of motorcycle dependence will be defined based on the average grade points (GPA). The motorcycle dependence is *"high"* if the GPA is higher than 2.5; the *"medium"* motorcycle dependence will be rated for the GPA that falls in between 2.0 and 2.5; and the *"low"* motorcycle dependence is defined for the GPA that is lower than 2.0.

3.1.3. Vehicle Ownership

- **Motorcycle Ownership**

Motorcycle ownership (MCO) is the most important indicator in defining motorcycle dependence. In Figure 3-2, the graph shows a general impression that the high MCO is coupled with low income (in term of GRP /capita) (Barter, 1999).



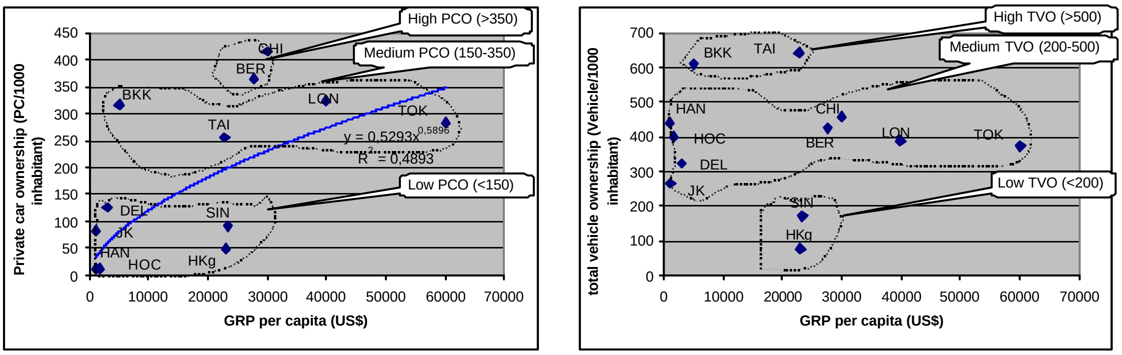
Note: HAN: Hanoi, 2003, HOC: Hochiminh City, 2002; TAI: Taipei, 2003; BKK: Bangkok, 2002; DEL: New Delhi, 2003, JK: Jakarta, 2001; SIN: Singapore, 2003, HKg: Hong Kong, 2003; BER: Berlin, 2003; CHI: Chicago, 2000, LON: London, 2003; TOK: Tokyo 2003. [Data source: see [1]]

Figure 3-2: Motorcycle ownerships and GRP per capita in the selected cities

This conclusion is right for the cases of Hanoi and Hochiminh City, Bangkok, New Delhi or Jakarta, but it is wrong for the case of Taipei, which indicates that a high-income city also has high MCO, 378 MCs/1000 inhabitants. The data also shows that the highest income city, Tokyo, also has the highest MCO among the group of high income and low MC cities.

- **Passenger Car and Total Motorised Vehicle Ownership**

The left hand side graph in Figure 3-3 shows that no Asian city belongs to the group of high passenger car ownership (PCO) and most of high MCO cities belong to the low PCO group, except Taipei. Berlin and Chicago are among groups of medium PCO in their country, Germany and the USA, but they are leading in this comparison. The trend line seems to indicate that higher income cities have higher PCOs. However, the low R-square value does not prove the significance of that relation. In fact, the data shows that the highest income cities (Tokyo, London) do not have PCOs. In contrast, the PCO of Bangkok (a low-income city) is much higher than that of Hong Kong or Singapore.



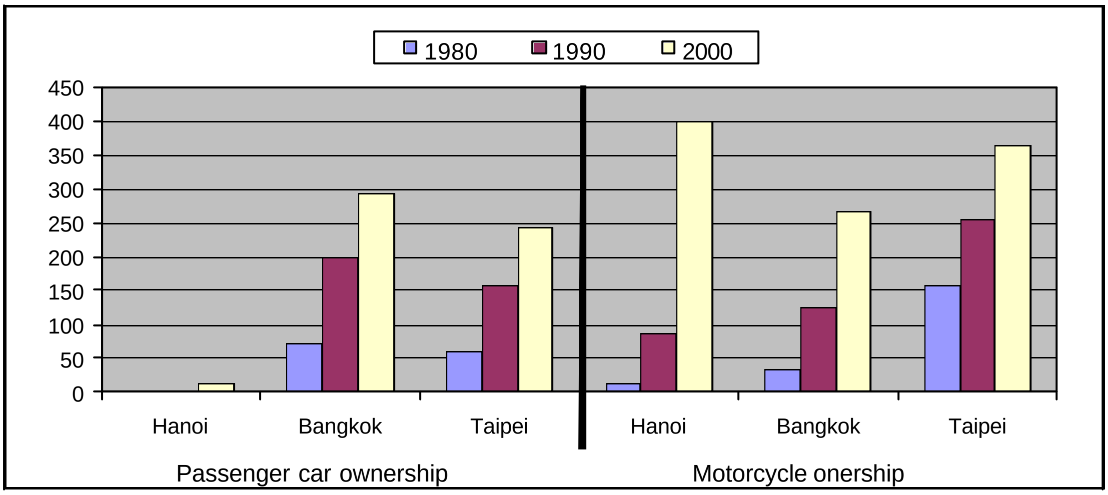
[Data source: see [1]]

Figure 3-3: Car and total motorised vehicle ownership in the selected cities

The right hand side graph indicates that the vehicle ownership in a city is not affected by the level of income, especially in the cities with high motorcycle ownership. The total vehicle ownerships (TVO) of Bangkok and Taipei are much higher than the saturation value, 550 vehicles/1000 inhabitants (see Buchanan, 1963).The medium TVO cities are divided into two sides, one side consists of the low-income cities (Hanoi, Hochiminh city, Delhi, Jakarta), and the other includes the high-income cities (Berlin, London, Chicago and Tokyo. Hong Kong and Singapore have low TVOs, while their GRPs are high.

- **Trend in Vehicle Ownerships**

Data of Hanoi, Bangkok, and Taipei were collected representatively in order to analyse the trend in vehicle ownership of the cities. Hanoi is a low income and high MCO city, Bangkok has a medium income and medium-high PCO, and Taipei has a high-income and medium-high in both MCO and PCO.



[Data source: see [2]]

Figure 3-4: Changes of vehicle ownerships of the selected cities (1980-2000)

The data of Hanoi shows a very high rate of annual increase of motorcycle fleet in Hanoi during 1980 and 1990, of 22% per year. The rate in the next decade was lower but still of about 13.5%. The absolute number of cars in Hanoi at the end of 2000 was still small but the growth rates were continuously very high during 20 years. If the rate stays the same for next decades, the PCO in Hanoi would be placed at 165 cars/1000 inhabitants in 2020 and 611 cars/1000 inhabitants in 2030.

Due to a free motorisation policy, the PCO in Bangkok and Taipei was increasing quickly during the period 1980-2000. If the trends remain in both cities, the PCO in Bangkok and Taipei would reach 430 and 379 in 2010, respectively. The MCO growth rate in Bangkok was higher than that of PCO during twenty years and it was drastically increased during 1998-2000 due to the Asian economic crisis (UNEP, 2002a). If the trend would remain, the MCO in Bangkok would be up to 504 and the TVO would come to 934 in 2010. The changes of MCO in Taipei indicate a stable development of motorcycle fleet in the period 1980-2000, about 4 to 5% per year. If the trend would remain, the MCO and TVO in Taipei in 2010 would be 560 and 939 respectively.

3.1.4. Availability of the Transport Alternatives to Motorcycle and Car

- **Public Transport Services**

Railway Transit

In the high MCO group, including Hanoi, Taipei and Hochiminh City, the urban rail transit exists only in the Taiwanese capital, since 1990s, the tramways were removed from Hochiminh City during 1950s and from Hanoi in early 1990s (Hung, Truong et al., 2001, 2002). In the medium MCO group, the urban rail transit (URT) was rebuilt in December 1999 in Bangkok, and the one in Delhi is still under construction. The high investment cost is one of the reasons that do not allow the URT to become popular in developing cities. For the case of Taipei, PADECO (2000) found that the city government began to develop urban rail transit quite late. Today, only six URT lines serve a city of 2.6 million people.

Table 3-2: Public transport availability in some Asian cities

City	Transit service				Paratransit services			
	HRRT*	LRT*	Standard buses	Minibus	Ordinary taxi	Motorcycle taxi	Motorized tri-cycle taxi	Non-motorized tricycle
Hanoi 2004	0	0	687		2,500	10,000	0	3,000
Hochiminh 2002	0	0	444	1,892	3,579	20,000	30,000	
New Delhi 2000	1	0	1,932	11,068	8,000	N/A	45,000	
Bangkok 2003	1	1	21,671	7,490	10,606	N/A	7,382	0
Taipei 2003	6	0	6,092	0	34,584	N/A	0	0

Note: HRRT: Heavy Rail Rapid Transit, LRT: Light Rail Transit, N/A: Not available; * counting in number of route,** Number of buses in Taipei included business buses [Data source: see [3]]

Bus Transit

Data in Table 3-2 shows that the bus service is the major transit service in these cities, but this service was degraded for the last two decades of the 20th century (Barter, 1999; Aggarwal, 2001). Recently, governments of Taipei and Bangkok have carried out some public transport encouraged measures, such as bus exclusive lane or provision of air-conditioned buses, in order to improve the attractiveness of the bus service.

As the major public transport mode, the bus ownership (BO) is selected as the representative for the general indicator public transport ownership. Hanoi, Hochiminh City and Delhi are in the low BO group by having less than one bus per 1000 inhabitant. It is necessary to emphasise that, the data of New Delhi is mixed between standard buses and minibuses. According to Aggarwal (2001), the number of standard buses in this city is about 2000 units. The data shows that, Bangkok owns the highest value of BO among the cities, of 2.42 buses per 1000 inhabitant. It is interesting to see a high BO in Taipei (2.32). It shows that public transport and motorcycle can be integrated peacefully in an urban transport system.

Minibus

Called as Xe Lam in Hochiminh City, Song Theo in Bangkok, or Phatphat in Delhi, the minibus service has played a significant role in the public transport of the cities, except in Hanoi and Taipei. This mode can be considered as the main road based public transport service in New Delhi and other cities in the South Asia region (Bose and Sperling, 2001). In Hochiminh City and Bangkok, this mode is quite active in the sub-urban area. However, the pollution, low vehicle quality, and accidents have made the mode less attractive in most of cities where it is operating.

Paratransit

Ordinary taxi in these cities is reliable, but its cost doesn't allow many of the ordinary people to use. For high income people, the ordinary taxi service is recognized as the best public transport service in Bangkok, Taipei, Hanoi or Hochiminh City(Hung, Truong et al., 2001, 2002; Hsu, Shadullah et al., 2003).

Motorised tri-cycle, called Xe loi in Hochiminh City, Tuk Tuk in Bangkok or motor-Rickshaw in New Delhi, is available in most of the cities in the South and Southeast Asia. The non-motorised tricycle is available in the lower income group of the first three cities, and it is a major paratransit in New Delhi and other South Asian cities.

There are scientific proposals to encourage non-motorised tricycle and to develop the gas-motorised tricycle in South Asia (Aggarwal, 2001). However, these two modes are not preferred by the city governments and people, who believed that the modes pollute the air, create traffic congestion, and present an image of low income and poverty (Barter and Road, 2000). On the other hand, the travel cost and road space consumption of these modes is higher than motorcycle. Therefore, they are strictly prohibited on the main streets and in the centre of some cities, for example, Hanoi and Hochiminh.

The motorcycle taxi is the unique paratransit mode of the Southeast Asian cities. Having a reasonable speed, being more flexible and much cheaper than the ordinary taxi, the motorcycle taxi is favoured by the citizens and the tourists. It does not look so safe, but the rate of accidents related to motorcycle taxi drivers is significant low (JICA and TDSI, 2004).

(a) MC taxi in Bangkok (Into-asia, 2005)

(b) "5 in 1" MC taxi in Jakarta (Punklett, S. 2004)

(c) Rickshaw in New Delhi (Aggarwal, 2001)

Figure 3-5: Paratransit in the motorcycle dependent cities

It is interesting that this mode likely doesn't exit in Taipei, and no information about motorcycle taxi in New Delhi is available. Unfortunately, no city has ever counted the motorcycle taxi as an official public transport mode.

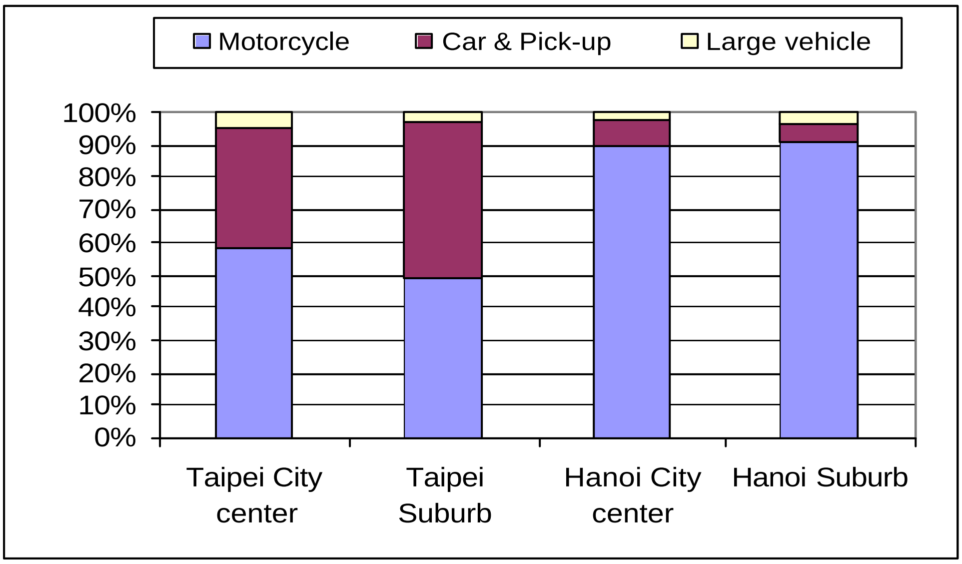
- **Non-motorised Transport (NMT)**

The NMT here presents only the individual bicycling and walking. In the motorcycle dependent cities, the NMT has low favour from both, government and people. In the users' viewpoint, the motorcycle requires the same lane width and parking area, but it is faster in travelling and better in carrying goods or additional passenger. Therefore, the motorcycle is considered as the modern substitution of bicycle. In the political views, many governments in this region consider "NMT is associated with poverty, and this association tends to make it something 'planned against' rather than 'planned for", World Bank (1996). Imported computerised car-based transport planning methodologies completely ignore the existence of NMT(Newman and Kenworthy, 1999). The investment for road infrastructure is focused to expand roads serving motorised traffic while neglecting waling, cycling and public transport (Barter and Road, 2000). These trends and policies are not only discouraging, but they also actually replace the NMT and reduce the variety of transport alternatives. For example, in Hanoi, the number of bicycle was reduced from 1 million in 1989 to 790,000 in 1994 (JICA and HAPC, 1997). The pedestrians are in-directly discouraged during second half of 20th century in Bangkok and Taipei by the motorization and vehicular traffic infrastructure investment policies (Barter, 1999; Rujopakarn, 2003).

3.1.5. Motorcycle Use

- **Share of Motorcycle in the Traffic Flow**

As presented in Figure 3-6, motorcycles are counted for about 90% of the motorized vehicular trips in all areas in Hanoi. This share was significantly increased from 50% in 1995 (JICA and HAPC, 1997). Based on the motorcycle share in the traffic flow, Hsu, Shadullah et al. (2003) concluded: "Vietnamese people are being most motorcycle depended" in their comparative study on motorcycle traffic between Taiwan, Vietnam and Malaysia. Generally, the share of car is still low, while the figure in the city centre is higher in other areas.



Note: Hanoi's data was collected in 2004 (JICA and TDSI, 2004), Hang Bong Street and Kim Ma Street (City centre); Cau Giay Road and Truong Chinh Road (Suburb). Taipei's data was collected in 2002 (Hsu, Shadullah et al., 2003), Nan King W. Road & Chen De Road Intersection (City Centre), Ta Du Road & Chung Yen Road Intersection (Suburb).

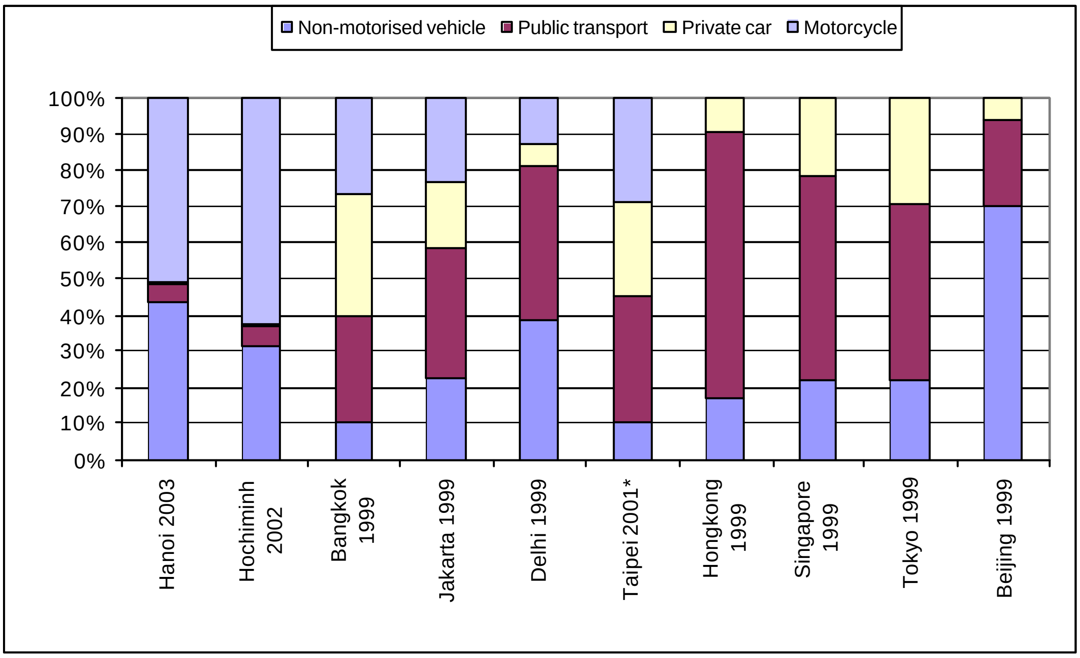
Figure 3-6: Vehicle composition of the traffic flows in Hanoi and Taipei

The share of motorcycles in the traffic flow in Taipei is also at the high level, and the motorcycles are more favoured in the high-density urban area than in the dispersed suburbs.

- **Modal Split**

The modal split is an important indicator that presents the actual use of the citizens on certain means of transport. The following sections will discuss over modal split of main passenger transport modes in some Asian cities and focus on the modal split of motorcycle in comparison with other motorised passenger transport.

Data on general modal split shows a clear picture of what were defined by Barter (1999) as *bicycle city* (Beijing) and *pubic transport city* (Hong Kong, Singapore, Tokyo). The relative high shares of non-motorised transport (NMT) in Hanoi, Hochiminh City and Delhi have a historical reason. These three cities depended on NMT before 1980. Bangkok and Taipei is heavily dependent on individual motorised vehicle (IMV) and the capital of Indonesia would follow suit if there were no significant effort in reducing the use of the IMV.



Note: The modal splits of Hong Kong, Singapore, Tokyo, Beijing are NMV, Public Transport and Individual motorized transport (car and MC), the NMV modal split of Taipei is assumed about 10% total passenger transport demand; [Data source: see [4]]

Figure 3-7: Modal split in passenger transport in some Asian cities

The updated data on NMT modal split of Taipei is not available, but there is evidence of low NMV split in the passenger transport of this city. PADECO (2000) provided modal split of all transport modes other than Public transport, car and motorcycle is 14.3% in 1980 and 12.1 % in 1990. Therefore, in the graph, the NMV modal split of Taipei is assumed about 10%.

Modal Split of Motorcycle

The data of Hanoi and Hochiminh City showed their high modal split of motorcycles, while the modal split of private cars is still very low. Among the individual transport modes, the modal splits of Bangkok and Taipei look balanced between motorcycles and cars. However, the motorcycle has a more important role in Taipei than in Bangkok. The above analyses show that the increase of motorcycle domination in the vehicle fleet proportionally supports the increase of MC modal split.

3.1.6. Concluding Remarks

As the conclusion of this section, a typical motorcycle dependent city has the following characteristics:

- Motorcycle ownership is higher than 350 MCs per 1000 inhabitants,
- Private car ownership is lower than 150 PCs/1000 inhabitants,
- Public bus availability is lower than 1 bus/1000 inhabitants (a bus-based urban transit system),
- Non-motorised transport is available but incompetent in comparing with motorcycle
- Motorcycle share in the traffic flow is higher than 50% and,
- Modal split of motorcycle is higher than 40%, while modal splits of private car and public transport are lower than 20% and modal split of non-motorised transport is about 30% to 50%.

Table 3-3 indicates that Hanoi and Hochiminh City in Vietnam are typical motorcycle dependent cities. New Delhi and Jakarta have high level of public transport use but the availability of public transport services in these cities is still insignificant. Bangkok and Taipei have very high TVO and they have an image of individual motorised transport city.

Table 3-3: Motorcycle dependence of selected Asian cities

Indicators			City											
			Hanoi		*Hochiminh*		Delhi		Jakarta		Bangkok		Taipei	
Main criteria	Sub-criteria	Measurements	*Value*	*Grade point*	*Value*	*Grade point*	*Value*	*Grade point*	*Value*	*Grade point*	*Value*	*Grade point*	*Value*	*Grade point*
Vehicle ownership	Motorcycle ownership (MCO)	MCs/1000 inhabitants	***400***	***3***	***371***	***3***	174	2	165	2	266	2	379	3
	Private car ownership (PCO)	PCs/1000 inhabitants	***12***	***3***	***12***	***3***	82	3	125	3	316	2	257	2
Availability of alternatives to IMV	Bus transport availability (BO)	Buses/ 1000 inhabitants	***0,23***	***3***	***0,08***	***3***	0,9	3	N/A	-	2,4	1	2,32	1
	Bicycle availability (BIO)	Bicycles / 1000 inhabitants	***N/A***	***-***	***N/A***	***-***	N/A	-	N/A	-	N/A	-	N/A	-
Use of motorcycle	Motorcycle share in the traffic flow	% of MCs in the traffic flow (in vehicle unit)	***90%***	***3***	***87%***	***3***	N/A	-	N/A	-	N/A	-	58%	3
	Modal split of Motorcycle	% of trips by MC	***51%***	***3***	***63%***	***3***	13%	1	23%	2	27%	2	29%	2
	Modal split of Public Transport	% of Trips by Public transport	***5%***	***3***	***6%***	***3***	42%	1	36%	2	30%	2	35%	2
	Modal split of Private Car	% of trips by cars	***1%***	***3***	***1%***	***3***	6%	3	18%	3	33%	2	26%	2
	Modal split of NMT	% of trips by NMT	***44%***	***1***	***32%***	***2***	39%	2	22%	2	10%	3	10%	3
Average grade point			***2,75***		***2,88***		**2,14**		**2,33**		**2,00**		**2,25**	
Motorcycle Dependence Level			***High***		***High***		**Medium**		**Low**		**Low**		**Medium**	

However, the case of Taipei is much better than Bangkok. The Taiwan's capital has much better public transport service, lower PCO and high MCO. For the last decade, Taipei has been recognised as a successful case in regulating motorcycle traffic and promoting public transport (PADECO, 2000), while Bangkok was called "car dependent city" since 1995 (see Kenworthy, 1995), and later, this city was defined as a "traffic saturated city" (Barter, 1999).

3.2. Transport Problems in the MDCs

3.2.1. Traffic Accidents

- **Overviews**

As indicated in Table 3-4, the rate of fatalities per 10000 inhabitants in Hochiminh City is about 10 times higher than that in Berlin, or about seven times of Taipei's rate. The data shows a safer traffic in Hanoi in comparing with Hochiminh City and Bangkok, but the situation is still very serious.

Table 3-4: Traffic accidents in selected cities

	Number of accidents	Number of injuries	Number of fatalities	Fatalities per 10.000 inhabitants	Fatalities per 10.000 vehicles
Hanoi 2004*	1399	1288	452	1,51	3,42
Hochiminh City 2001*	2519	1980	1224	2,23	5,56
New Delhi 2004	5083	-	1832	1,22	4,63
Bangkok 2001	45711	22854	1519	1,72	2,81
Tai pei 2003	143	57	87	0,33	0,52
Berlin 2003	16272	16693	77	0,23	0,54

Note: * indicated only severe injured and fatal accidents, [Data source: see [6]]

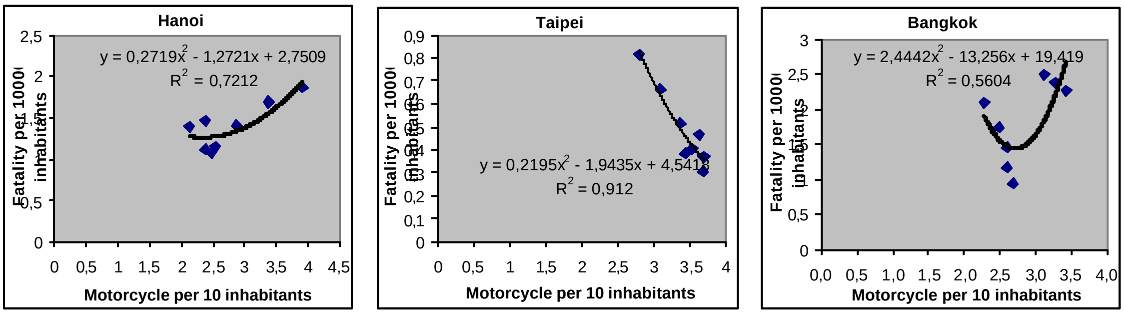
According to Du (2002) and Vi (2002), most of the severe accidents occurred in the suburban areas, and on the urban arterials, where the traffic speed is faster in the condition of mixed two lane undivided highway and higher share of heavy vehicles. For example in Hanoi in 2002, 65.2% accidents occurred on the national highways and sub-urban highways, 24.9% were accounted for urban roads and only 9.9% accidents occurred on the alleys. Data also showed that 34.76% severity accidents occurred during night-time (20:00 to 6:00) and about 31.82% occurred in the off-peak period (10:00 to 17:00).

Figure 3-8: Traffic accidents in Hochiminh City

Although the accident risk of motorcycle traffic is high in general, the data of Taipei shows an acceptable situation, while the fatality's indexes of Taipei are close to the figure of Berlin, a developed city with modern transit systems and very low motorcycle use. Traffic in Taipei is also much safer than in Bangkok or New Delhi, where the motorcycle uses are significantly lower than that of Taipei. This case proves that a city can maintain safe traffic in the situation of high MCO.

- **Relations between Motorcycles and Accidents**

In MDCs, motorcycles are the main participants of the traffic accidents (Shah and Iyer, 2002). For example, in Hanoi, the motorcycles are related to 68 % total cases of the road accidents (Du, 2002) and the four-wheelers participated in 29.4%. Analysing 374 severe accidents in Hanoi in 2002, the first rank is careless observation (44.7%), overriding on the opposite direction (22.2%), over passing (6.7%), turning (4.8%), ranked at the last is over speeding with only 2.9%. The data analysis shows a clear evidence of immature behaviours of road users in the MDCs and lack of effective enforcement.



[Data source: see [6]]

Figure 3-9: Relationships between MCO and traffic accident fatality

The graphs in Figure 3-9 are developed by the statistical data between 1995 and 2002 in Hanoi, Bangkok and Taipei. Although the polynomial regression forms had been presented as having the best R-square value, the relationship between MCO and fatality index in Bangkok is not significant. The case of Hanoi indicated that the increase of MCO and the fatality index is proportionally related, while the situation of Taipei is opposite. The Taipei's graph proves that the traffic safety can be improved according to the maturation of road users behaviours in response to the motorisation process in transport.

3.2.2. Traffic Congestion

- **Traffic Flow**

Mixed Transport Technologies in the Traffic Flow

The urban traffic flow in the MDCs is mixed of different transport modes and different levels of vehicle technologies, especially very old and very new. JICA, MOT et al. (2004) saw about ten transport modes that operate simultaneously on the traffic flow of a common urban road in Hochiminh City, including motorcycle, car, truck, bus, Lambro, motor-tricycle, bicycle, tricycle, animal-pulling vehicle, and man-pulling vehicle. Gakenheimer (1999) referred to the observation of Darbera and Nicot (1984) that found sixteen different types of vehicle being used on the urban road in India. There are many incompatibilities between the physical features and dynamic characteristics of a motorcycle and a car, a bicycle and a car, a motorcycle and a truck, a motorcycle and a bus.

The mixed traffic causes congestion in the urban area and severe traffic accidents on the main arterial roads. The segregation between modes requires at least two separate traffic lanes (one for car and buses and one for motorcycles) plus one bicycle lane. However, this requirement is quite difficult for MDCs where the GRP per capita is only US$ 1.000.

Extremely High Traffic Volume

With the domination of motorcycles in the traffic flow, the urban road in MDCs can smoothly handle an extremely high personal travel demand. Figure 3-10 shows the results of a traffic count survey at cross section 599 Kim Ma in Hanoi. One can see that two standard traffic lanes (3.5 meters lane width) and one bicycle lane (1.5 meter) handled approximately 14.500 vehicles or 23,300 persons in one hour during the morning peak period.

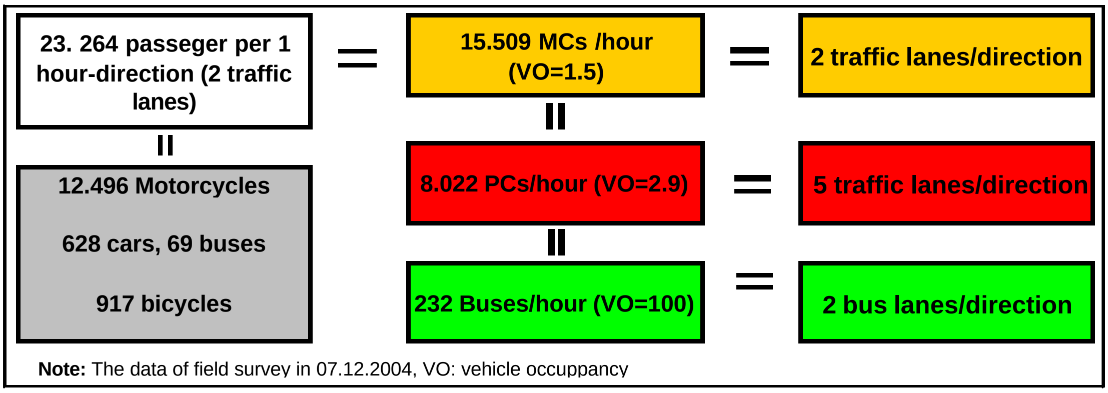
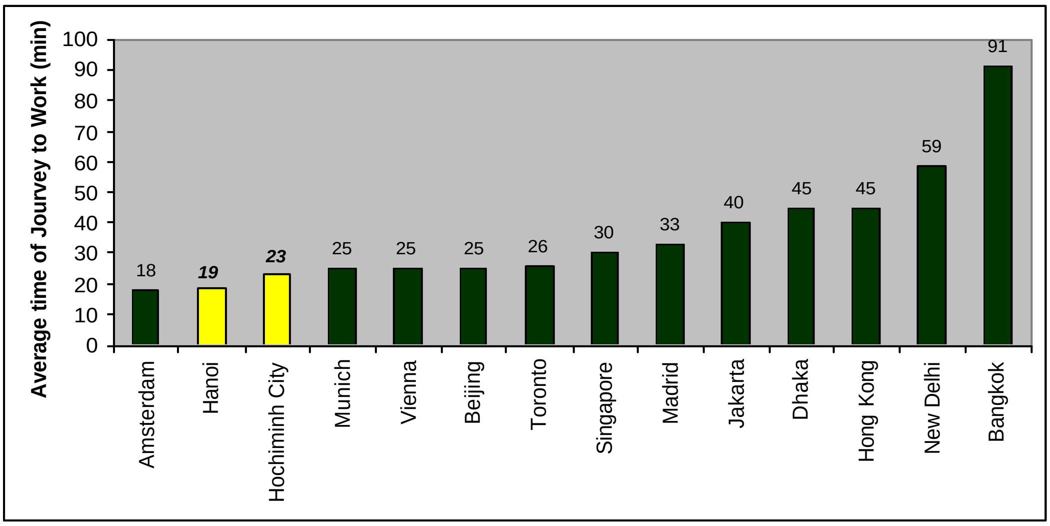


Figure 3-10: Inbound traffic volume on Kim Ma Street in the morning peak-hour

The conversions of traffic volume into passenger cars and buses and the required road capacity for handling the flow indicate that the motorcycle is the most efficient road transport mode in terms of space utilisation. Unfortunately, there is no data about traffic flow on the alleys as well as no evidence about traffic congestion on this type of roads.

- **Travel time**

In MDCs, the average trip time is short with a reasonable speed and a short trip distance.



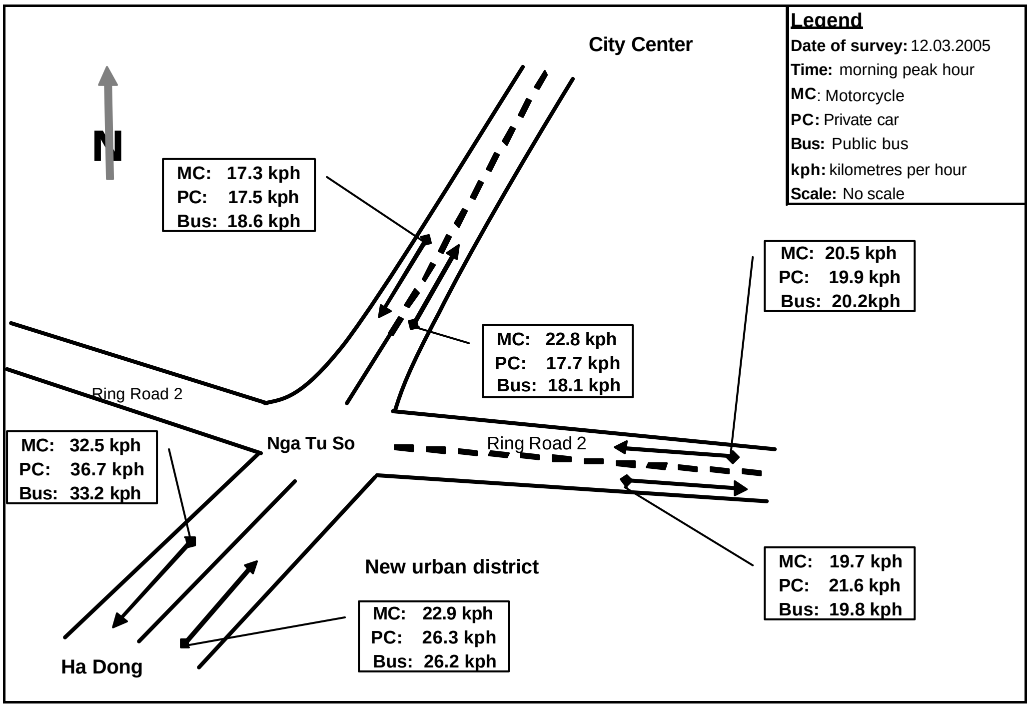
Note: Data in Hanoi and Hochiminh were collected in 2005 and 2002 (JICA, MOT et al., 2004; JICA and HAPC, 2006), Data of other cities were collected in 1990 (Gakenheimer, 1999))

Figure 3-11: Comparison of average working trip time between MDCs and other cities

For example, in Hochiminh city, the average Journey-To-Work time is about 23.4 minutes per trip, this is slightly shorter than the average travel time in Germany, about 23.6 minutes per trip (BMVBW, 2004), and significantly shorter than the travel time in many other cities in 1990 (see Figure 3-11). According to JICA, MOT et al. (2004), the average travel time for a single trip by motorcycle in Hochiminh City in 2002 was only 18.1 minutes and more than 93% road users were satisfied with their daily travel time consumption.

- **Traffic speed**

As indicated in Figure 3-12, the average speeds of different transport modes in the most congested corridor in Hanoi during morning peak hour are quite reasonable in comparison with the average travel speed in other developing cities in Asia.



[Data source: (JICA and HAPC, 2006)]

Figure 3-12: Average travel speeds in the corridor Ha Dong- City centre in Hanoi

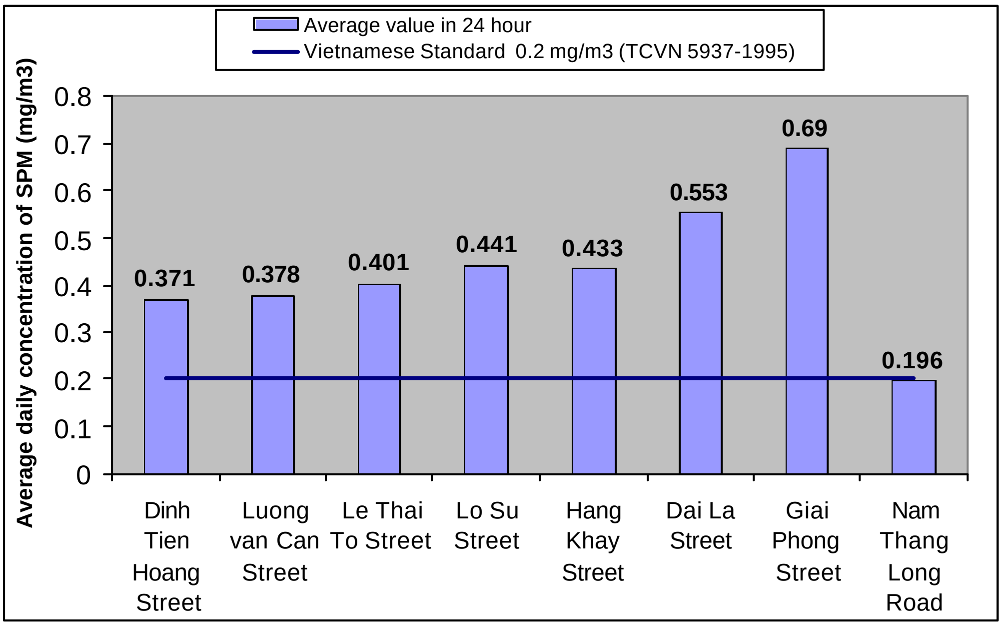
According to the data of Bangkok Metropolitan Administration (2002), the inbound car speed on the Paholyothin road (main arterial to the Don Muang Airport) was about 17.25 kph in the morning peak hour (outbound speed was 22.59 kph). The average car speed in the city centre of Bangkok was much lower and between 6.84 kph (Silom Road, Outbound, morning peak) to 16.84 kph (Sukhumvit Road, Outbound, morning peak). In the urban area of Manila metropolitan, the average car speed in the morning peak period in 1996 was about 14 kph (JICA, MOT et al., 2004) and the bus speed was only about 17 kph (Barter and Kenworthy, 1997). The data showed that the average traffic speed in Hanoi in 2005 is not so different from that in Tokyo in 1990, about 20 kph (Barter and Kenworthy, 1997). The average motorcycle speed in Hanoi is also similar to that of Taipei, 19.1 kph (Tzeng and Chen, 1998).

Data in Hanoi indicated a stable mobility condition of travel between 1995 and 2004. During this period, the number of motorcycles in Hanoi increased for 2.5 times but the average peak-hour speed of motorcycles there is almost unchanged (average speed of MC in 1995 was 22.5 kilometres per hour) (JICA and HAPC, 1997). According to Örn (2005), the high use of motorcycles is counted as the main reason to maintaining the reasonable traffic speed in Hanoi during this period. However, there are signals of severe traffic congestion in MDCs with the higher share of car in the traffic flow. In the latest traffic speed study in Hanoi, at the most congested sections, where the average speeds of motorcycles are lower than those of cars and less than 15 kilometres per hour (JICA and HAPC, 2006), the share of cars in the traffic mix are much higher than the average value in overall urban area of Hanoi.

3.2.3. Environmental impacts

- **Air Pollution**

There are different opinions about air pollution caused by the motorcycle traffic. The first one accused that the motorcycle creates serious air pollution in the urban area (Barter, 1999; Shah and Iyer, 2002). Some findings indicated that the Suspended Particulate Matter (SPM) is the most serious problem of motorcycle emission. The data showed that motorcycles and three-wheel vehicles produced 63% total traffic's SPM in New Delhi in 2000. In Bangkok Metropolitan Area, UNEP (2002a) reported that motorcycles produced 48% SPM, 60% of Hydro Carbon (HC) and 20% of Carbon Monoxide (CO) of total transport emission. In terms of air pollution, Taipei is no more a positive example, ninety percents of air pollution in Taipei are emitted by transport (PADECO, 2000).



[Data source:(Luu, Nguyen et al., 2001)]

Figure 3-13: SPM concentration in selected roads in Hanoi in 1998

The other sources of findings expressed an opposite opinion about air pollution of motorcycle traffic. In Hanoi, data in 1998 showed that the average 24-hour concentration of SPM in the roadside air of Hanoi was significant higher than the standard, except in the suburban area (Nam Thang Long Road, Figure 3-13). However, the main source of SPM in Hanoi did not come from motorcycles that produced less than 10% of SPM in Hanoi (Hien et al, 2005).

The problems of other pollutants were also not so serious in comparison with the standard (Luu, Nguyen et al., 2001). For example, the ratio between monitored concentration and standard of Carbon Monoxide, Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) in the most polluted street in Hanoi (Giai Phong Street) were 3.6/5, 0.067/0.3, and 0.052/0.1, respectively. JICA, MOT et al (2004) found that the concentration of air pollution was still below the threshold as a whole in Hochiminh City, except some main congestion points. According to a study by Tran and Benkhelifa (2002), motorcycles accounted for 93% VOC, 92% HC and 70% CO of Hochiminh city traffic emissions, while the transport sector consumed only 19% of the total fuel consumption of this city.

- **Noise Pollution**

The noise pollution is the main disadvantage of motorcycle use. Most of findings in different cities showed that the motorcycle-dominated traffic is polluting the city environment by noise. The monitoring results in 1998 in the selected roads in Hanoi indicated that the average noise levels in both day and night times were much higher than the country's standards.

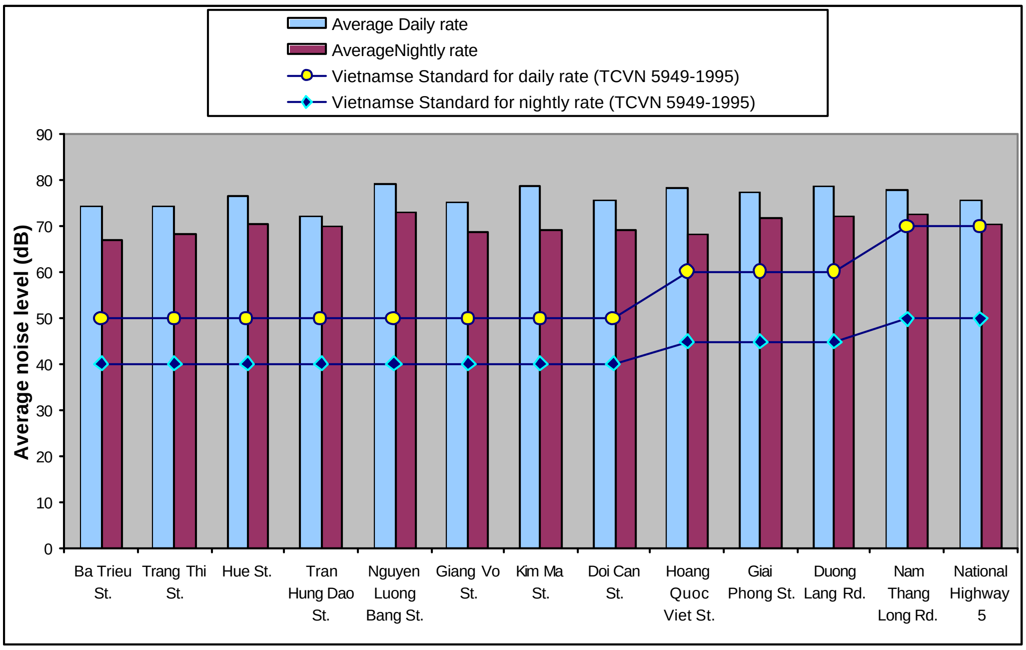


Figure 3-14: Noise level in selected roads in Hanoi in 1998

UNEP (2002a) presented a similar noise situation in Bangkok. The monitoring during 1996-2000 of Pollution Control Department presented the average 24-hour noise level in urban area of Bangkok of about 74-80A-weighted decibels (dBA), while the Thai standard figure is 70 dBA. In New Delhi, the situation was even worse. As presented in the White Paper of Pollution in Delhi (1998), the noise level of all major corridors in the urban area exceeded 100 dBA. The data showed that noise pollution is one of the serious problems of motorcycle traffic, especially where the number of two-stroke engine motorcycles is dominating (Shah and Iyer, 2002).

3.3. Urban Transport Conditions

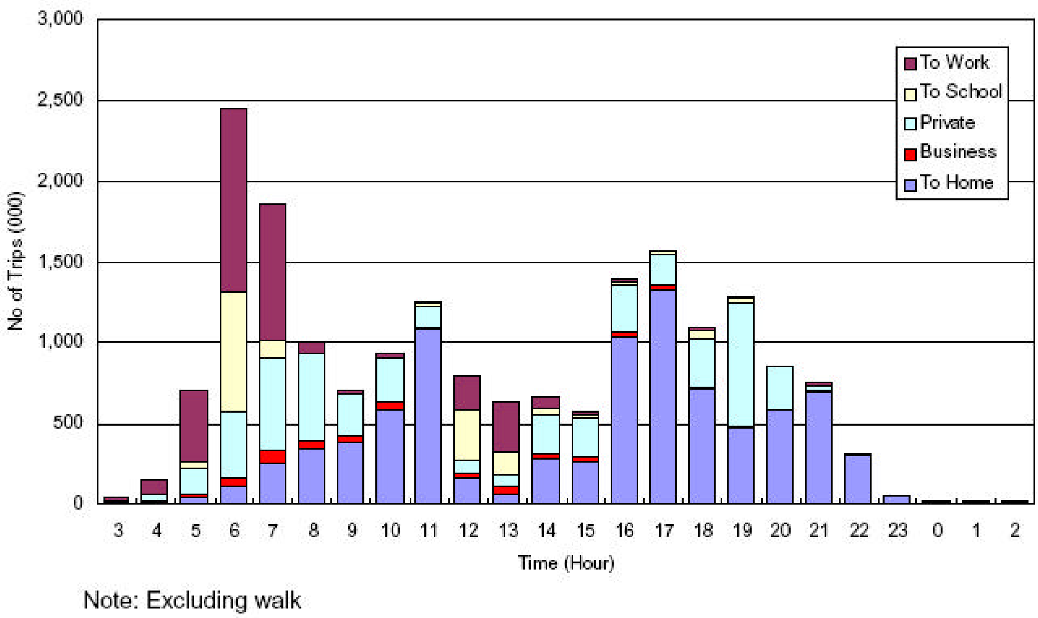
3.3.1. Travel Demand

Intensity of Travel Demand

The travel demand in MDCs is higher than many other developing cities (JICA, MOT et al., 2004). For example, the daily trip rates per person in Hochiminh city (2002) and Hanoi (2005) are 3,0 and 2,7 respectively, while the rates are 1,8 trips/person/day in Jakarta (2002), 2,3 trip/person/day in Bangkok (1995), and 2,2 trips/person/day Manila (1996). However, the daily trip rate in MDCs is significant lower than that in Germany, about 3.66 trips/person/day (BMVBW, 2004).

Hourly Distribution of Travel Demand

The hourly distribution of demand is seriously imbalanced, especially in the morning peak hours (JICA, MOT et al., 2004; JICA and HAPC, 2006). For example in Hochiminh city, 23% total daily travel demand occurred between 6:00 am to 8:00 am (see Figure 3-15).



[Source: (JICA, MOT et al., 2004)]

Figure 3-15: Hourly travel demand distribution in Hochiminh city in 2002

- **Behaviours of Drivers**

On the Road Links

In the MDCs, although the roads are either single or multilane, and the motorcycle is the major traffic mode, it is treated as an additional or minor player. The motorcyclists have no choice except 'zigzag" driving to avoid the conflicts with cars. The motorcycles are smaller than cars and the two-wheel bearer makes them much more sensitive for unbalance and out-of-control than the four-wheel vehicles. Therefore, the motorcyclists are also more sensitive to be injured in comparison with the car drivers. These disadvantages make the motorcyclists inevitable losers in the competition for road space with the car drivers. These also tend to encourage the aggressiveness of the car drivers.

Observing a multi-lane traffic flow in Hanoi, Bangkok, or Taipei, motorcycles normally have to drive on the side lane or in the area between cars, while cars and other four-wheel vehicles (much fewer in number) could easily take their advantages to driving on any lane (Hsu, Shadullah et al., 2003; JICA and HAPC, 2006). In addition, the buses manoeuvres, especially at the bus stops, look dangerous for motorcyclists, but only few accidents occurred due to this reason because motorcycles are flexible and their speed is relatively low, less than 30 kilometres per hour. Although the flexibility of motorcycles allows drivers to have higher mobility in the congested roads, it sometimes encourages the dangerous or illegal behaviours of motorcyclists.

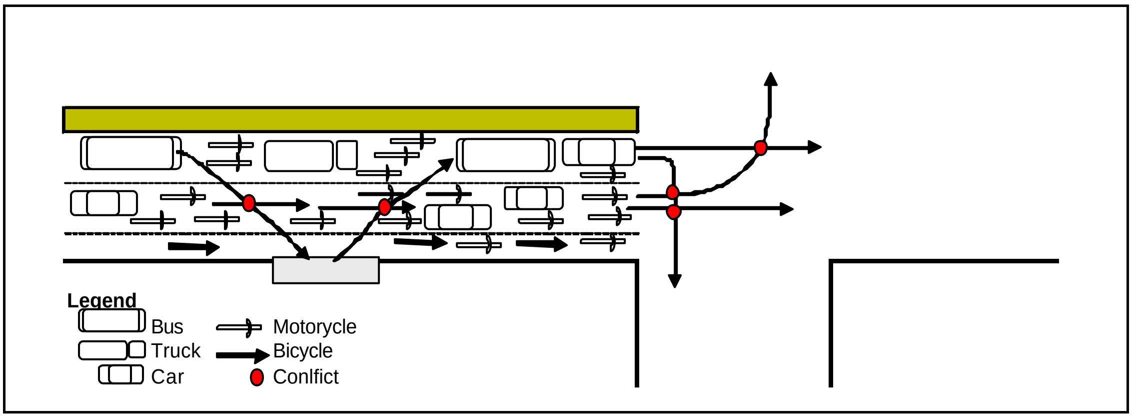


Figure 3-16: Behaviours on the road links and at the intersection

At the Intersections

At the intersections, motorcyclists will normally attempt to drive through the queuing four wheels vehicles to stop at the front the queue, see Figure 3-17. Those motorcycles will depart together within a very short time once the traffic signal turns to green. This phenomenon will generate a motorcycle wave immediately after the signalised intersection. Therefore, the starting delay of motorcycle at signalised intersections is shorter than that of the car (Hsu, Shadullah et al., 2003).

(a) At intersection in Hanoi, March 2003

(b) Situation in Taipei (Hsu, Shadullah et al., 2003)

Figure 3-17: Motorcycles at the intersections

The most difficult issue at the intersections is the high possibility of conflicts. In the MDCs, most of the signalised intersections have only two-phase signal program, which cannot eliminate the conflicts between the left turning and opposing straight vehicles. Uniqueness at the intersections of MDCs is the conflicts between through traffic movement and the right-turning vehicle (as presented in Figure 3-16). The situation could be worse at non-signalised intersections. The conflicts will cause congestions in the urban area, and serious accidents in the suburbs where the travel speed is higher.

U-turn Movements

According to Hsu, Shadullah et al.(2003), in Vietnam the U-turn of the vehicles is generally uncontrolled, the drivers can make u-turn at any place where there are not any physical obstacles for their movement. In contrast, the u-turn movement is fully controlled in Thailand, Malaysia or Taiwan.

On the Alleys

Motorcycles have an absolute advantage to drive on the less than 5-meter wide alleys. In case of no traffic regulation and enforcement available, the alley network is mainly occupied by the motorcyclists and many of them become very aggressive in the competition for space with pedestrians and bicyclists.

(a) Driving, transporting and parking in the alley

(b) on the sidewalk in Hanoi [Hung (2003)]

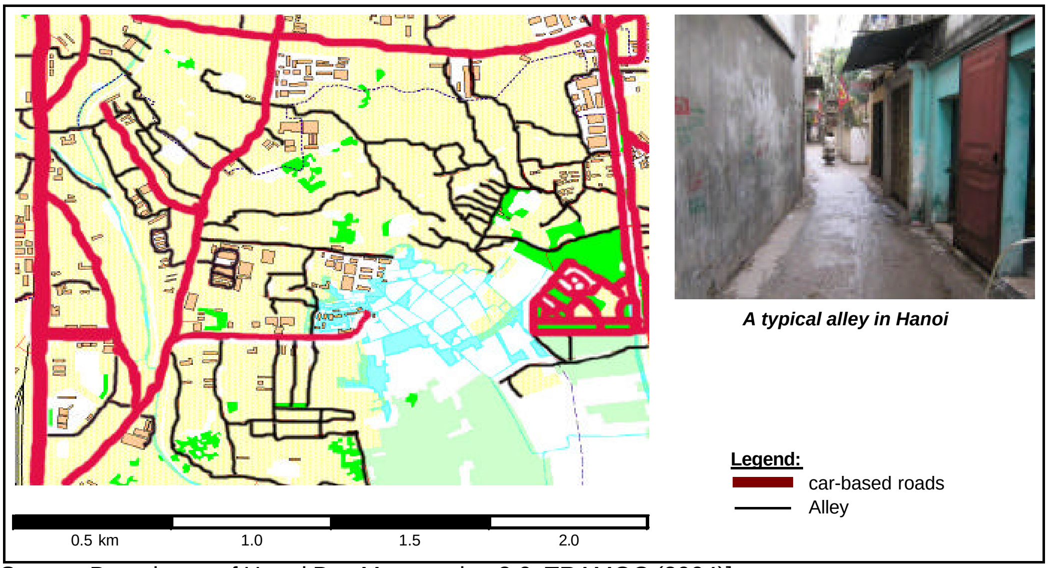
Figure 3-18: Behaviours of motorcyclists in Hanoi

3.3.2. Road Infrastructure

Road Network

The road network in MDCs is unbalanced and lack of a functional road hierarchical system (Hung, 2000). The imbalance of road is represented by road network density (RND) and the road occupancy area (ROA). It is usual that the old city centre has quite reasonable rates of RND and ROA, while the new developed areas have very low rates. For example, in Hochiminh city, the ROA of the old city centre is 11.4% while the rate of the inner fringes (developed after 1975) is only 2.9% and the newly development areas (developed after 1990) is only 0.4% (JICA, MOT et al., 2004). The lack of road hierarchy is presented by the large two-wheel accessed only residential areas, especially in the recent development urban areas, where people can access their houses via a network of alleys, which are less than 5 meters width (Figure 3-19).

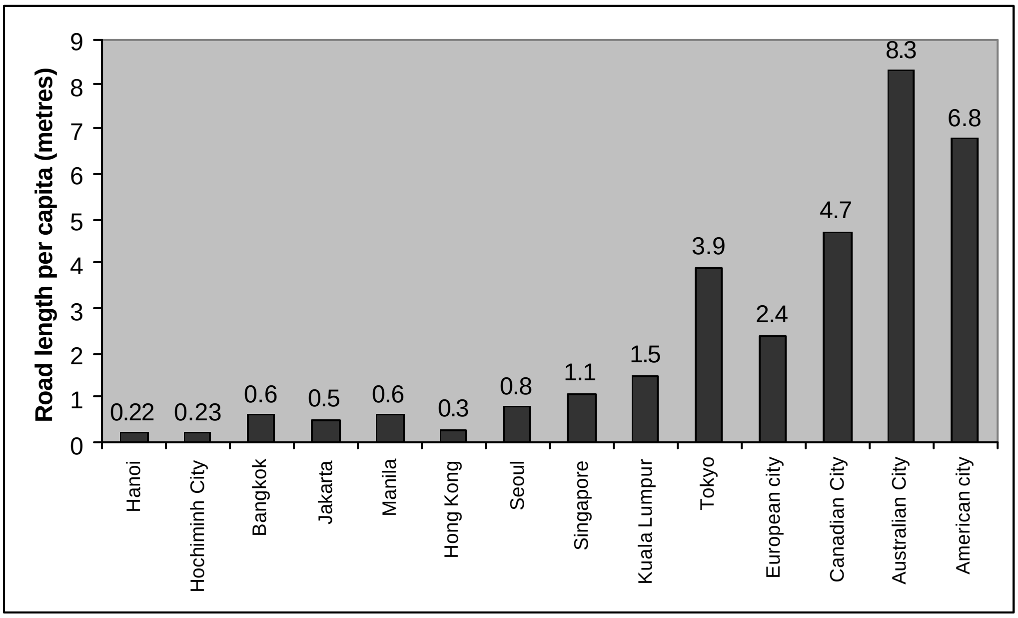
Four-wheelers can only access the first land use layer, while the deeper layers where almost 80 % of urban citizens are living today are impossible to access by car. Public transport can meet only the transport demand in a 300-500 meters buffer corridor, people in the deeper layers can only afford their transport demand by three main options: walking, bicycle and motorcycle. Therefore, the mobility of people tends to depend on the motorcycle that is much faster mode than walking or cycling. At this point, the use of NMV is strongly affected by an increase of motorcycles.



[Source: Based map of Hanoi Bus Map version 2.0, TRAMOC (2004)]

Figure 3-19: Network structure in the new development area of Hanoi

The provision of car-based roads in the MDCs is extremely low in comparison with other cities (see Figure 3-20). The average road length per capita in the MDCs is even lower than that of Hong Kong, the most transit oriented city among the selected group. The data show that, as similar to the transit oriented system, the motorcycle-dominated traffic fits well the condition of low road provision.



Note: Data of Hanoi and Hochiminh city were collected in 2004 and 2002; the alleys are excluded from data of these cities; Data of other cities were collected in 1990; [Data source:[9]]

Figure 3-20: Comparison of road provision in selected cities

Therefore, in any transport development plan in Hanoi, Hochiminh City, Bangkok or Jakarta, urban road construction is firstly prioritised (Wirahadikusumah, 2002; Rujopakarn, 2003; JICA, MOT et al., 2004; JICA and HAPC, 2006).

Parking facilities

The parking facilities in the MDCs are car-based and insufficient. Unfortunately, without available data on parking provision in the MDCs, it is difficult to make any comparison between parking in MDCs and other cities. The common image is that vehicles are parked in the streets (cars) and on the sidewalks (motorcycles and bicycles). In public area, the motorcycles are parked wherever possible, mostly on the sidewalks. At the activity centres (universities, shopping centres, hospital, parks, enterprises or offices), there are normally parking lots for motorcycles or sometimes they share the parking place with bicycles.

(a) Parking on the sidewalk in HCM city (2002) (b) Car parking on the bike-lane in Hanoi (2004)

(c) Public parking in the residential area in Hanoi (2004) (d) In-house parking in Hanoi (2005)

Figure 3-21: Parking in the MDCs

There are some public parking facilities, but they are provided without any plan. In the residential apartments, the parking services are normally provided irregularly by the families living on the ground floor. Few apartment blocks provide parking lots on the ground floor. In the other form of resident (houses), the motorcycles are frequently parked in the kitchen or living room on the ground floor, especially during night-time. The field survey in Hanoi showed that 73.2% of daytime and 97.5 % of night-time parking demands are in-house served (see Annex C).

The governments seem to ignore parking demand of motorcycles. For example, in the Master Plan of Public Parking Lots in Hanoi to 2020, there was no plan for motorcycle parking (Duy-Hung, 2004). Parking demand was also ignored in the planning studies conducted by foreign consultants. For example, in the Hanoi Urban Transport Master Plan

(1997) and the Hochiminh City Urban Transport Master Plan (2004), both were conducted by Japanese consultants, no sentence on parking could be found.

In general, the policies of governments in the MDCs discouraged the use of motorcycles (Chang, 2003; Hung and Thu, 2003), there is no exception for parking. Since January 2005, the motorcycle-parking fee begun in Taipei as a push measure to pull the passenger to the Mass Rapid Transit service (Taipei City Government, 2004). In Hanoi, the parking policies are giving much favour for cars. On-street parking for motorcycles is fully prohibited throughout the city, but cars are allowed to park in many streets. Since 2004, the parking prohibitions on the sidewalk were enforced on 125 urban roads in Hanoi. Motorcyclists are forced to park on the limited temporal on street parking bays or off-street parking lots, while the cars are allowed to park on the same roads. There is no signal of any additional parking places will be designed or provided for motorcycles in this city (Duy-Hung, 2004).

Intermodal Facilities

There is evidence about the practices of Park and Ride facilities for motorcycles in the MDCs. In Hanoi or Hochiminh City, at the main Bus or Railway stations, there are designated areas for bus/rail passengers to park their motorcycles or bicycles before riding. This measure is also applied successfully in Taipei (Yen, 2004). The intermodal transport concept is also working in MDCs. The practices of integration between public buses and motorcycle taxis are working very well in Bangkok, Hanoi and Hochiminh City. The integration between public buses and Tri-cycles are also practicing in New Delhi.

3.3.3. Public Transport Service

The availability of public transport service in MDCs has been expressed in section 3.1.4. Therefore, this section focuses mainly on describing the relation of public transport network and the city scale (in term of population) in MDCs. Figure 3-22 is a developed version from the presentation of Vuchic (1981) about proper transport infrastructure and main travel modes for different population scale of city. According to the condition of public transport development in MDCs, one can see that the bus-based public transport system in MDCs is suitable for a city with population less than 500.000 while most of MDCs having population more than 2 millions.

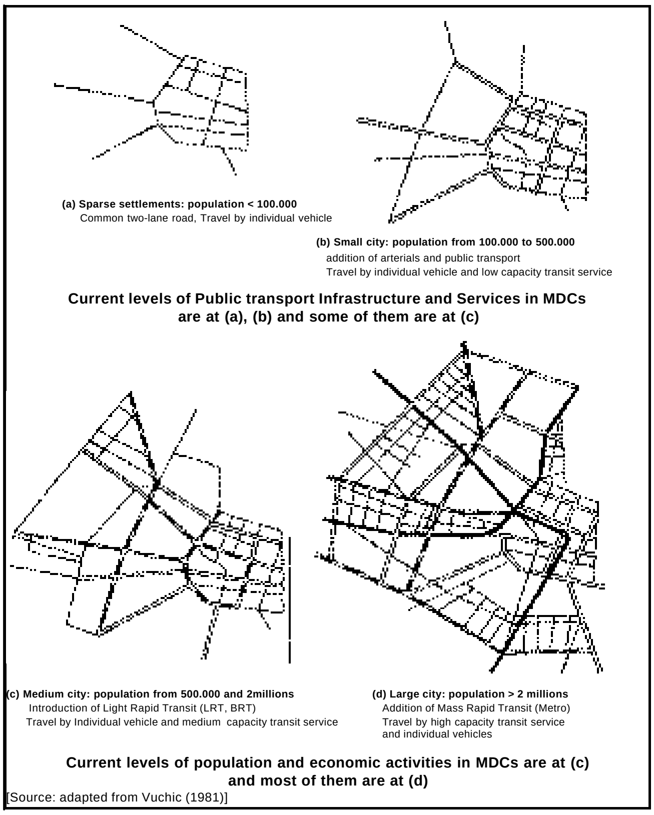


Figure 3-22: Public transport systems and city scale of MDCs

3.3.4. Traffic Management

- **Overview**

In MDCs, traffic management measures are perceived at different levels of application. Conventional traffic management measures appear more frequently as a concrete part of urban transport, for example, traffic signal control, one-way traffic, physical median, barrier, separated sidewalk, and etc. Many measures for public transport are presented there too. However, other dedicated traffic management measures are presented less frequently, some are presented by demonstration projects, and many are even totally absent.

Table 3-5 presents a perception about the appearance of traffic management measures in MDCs. Several measures are working well for motorcycle traffic in some cities. For example, the segregated motorcycle-lane on the urban arterials and two-step, left-turn movements are widely adopted in many cities in Taiwan. At the intersections, the left-turn movement is protected for cars and the motorcycles are strictly enforced to follow two steps left-turning process (Hsu, Shadullah et al., 2003). In fact, the Taiwanese system treats the motorcyclists as the second-class travellers, but it is still better than “nothing“.

In Vietnam, the too-wheel-only street or direction has been widely applied in the centres of both cities of Hanoi and Hochiminh. The recent adoption of segregated motorcycle lane in Hanoi was not successful due to a lack of Supportive Measures (enforcement, bus stop modification), but the public indicated no opposition to this measure. The sidewalk clearing measure is recently adopted in Hanoi and Taipei.

Regarding user control, wearing a helmet is a statutory requirement for all motorcyclists in Taipei, Bangkok, New Delhi and Jakarta when- and wherever they drive (Hsu, Shadullah et al., 2003). Since 2004, the Vietnamese motorcyclists are required to wear the helmet only on the rural highways (JICA, MOT et al., 2004).

In terms of emission control, there is no evidence in the MDCs about the existence of a motorcycle inspection system or the legal requirements of that. In Vietnam, most of the motorcycles have four-stroke engine but the situations in Thailand or India are different. According to Shah and Iyer (2002), 60% of the motorcycles in the South Asia have two-stroke engine that produces much more pollution than the four-stroke one. The Thai, Indonesian, and Indian governments are trying now to promote the use of four-stroke engine motorcycles. The engine capacity of motorcycles is strictly enforced widely in Vietnam and Taiwan. The normal citizens can only drive motorcycles with less than 150 cubic-centimetres engine. There is no such evidence of engine capacity control in India, Thailand or Indonesia.

Based on that perception, some general discussions about planning and implementation of the traffic management measures in MDCs can be drawn. These discussions focus mainly on the situation of traffic management in Hanoi and Hochiminh City, two cities having high motorcycle dependence. In addition, the information about traffic management in these two cities is up-to-date. At some points, information from other cities is referred to for comparison.

Table 3-5: Perception of traffic management in MDCs

No	Measures: Category	Measures: Title	Characteristic	City: Hanoi	City: Hochiminh City	City: Jakarta	City: Bangkok	City: New Delhi	City: Taipei
1	Public transport measures	Routing improvement	TE	X	X	X	X	X	X
2		Scheduling improvement	"	X	X	X	X	X	X
3		Physcial accessibility improvement	"	X	O	X	X	?	X
4		Transit Right of Way prioritisation	"	O	O	X	X	X	X
5		Transit user incentive	ECO	X	X	?	X	?	?
6		Transit operators encouragement	"	X	X	?	?	?	?
7		Public Transport Information Service	IN	X	X	?	X	?	X
8		Public transport management centre	A-O	X	X	?	?	?	X
9		Smart ticketing system	"	X	X	?	?	?	?
10		Paratransit regulation	"	X	X	X	X	?	X
11		Clean fuel bus	"			?	?	?	?
12		Low-floor vehicle (bus & tram)	"			?	X	?	?
13	NMT measures	Sidewalk and ped. crossing facilities	TE	X	X	X	X	X	X
14		Bicycle lane and facilities	"	X	X	?	X	?	X
15		NMV zone	"	O		X	?	?	?
16		NMV traffic information service	IN						?
17		NMV right of way reservation ordinance	A-O						?
18		Bicycle sharing service	"	X	X			X	
19	IMV measures	SOV right of way reduction/ HOV priority	TE			X			
20		Traffic Calming and Speed reduction	"	X	X				?
21		Segregated motorcycle lane	"	O	O	?	?	?	X
22		Head-starting zone	"	O	O	?	?	?	X
23		Urban Road pricing/ Tolling road	ECO		X	O	X	?	X
24		Parking pricing system	"	X	X	X	X	X	X
25		Taxes and duties	"	X	X	?	?	?	
26		Parking information service	IN			?	?	?	X
27		Motorcycle sharing	A-O	X	X	X	X	X	?
28		Parking regulation	"	X	X	?	X	?	X
29		Vehicle registration control	"	X	X	?	?	?	X
30		Two-stroke engine MC replacement	"	X	X	?	X	X	?
31	Intermodal & Multimodal measures	Ring road concept	TE	X	X	?	X	?	?
32		Elimination of bottlenecks on the links	"	X	X	?	?	?	?
33		Lane and direction management	"	X	X	X	X	?	X
34		Signalisation of Intersection control	"	X	X	X	X	X	X
35		Intersection geometrical modification	"	X	X	X	X	X	X
36		Intermodal facilities	"	X	X	X	X	X	X
37		Road safety audit	"			?	X	?	?
38		Urban traffic information service	IN			?	X	?	X
39		*Land use changes*	A-O						
40		Flexible working and school hour	"						
41		Traffic law improvement	"	O	O	X	X	X	X
42		Enforcement improvement	"	O	O	X	X	X	X
43		Traffic education	"	O	O	?	?	?	X
44		Traffic emmergency and rescue service	"	O	O	?	?	?	?
45		Vehicle standard and inspection improv.	"	O	O	?	X	?	X
46	Freight transport	City logistic management system	TE	X	X	?	X	?	X
47		Urban truck traffic control	"	X	X	?	X	?	?
48		Delivery service regulation	"			?	?	?	?

Note: **X =** Application, **O =** Proposed or Trial Project, **?=** No information, **Blank =** No application
IMV = Individual motorised vehicle; **NMT =** Non-motorised transport

[Data Source: (Barter, 1999; Hung, 2000; PADECO, 2000; Hsu, Shadullah et al., 2003)]

- **Planning of Traffic Management Measures**

There are three major approaches in planning traffic management measures in MDCs. The first approach is to integrate the conventional traffic control and operation measures in the infrastructure or public transport development projects. For example, the Traffic Management Plans within the urban transport development plan in Hanoi in 1997 and Hochiminh city in 2004 (see JICA and HAPC, 1997; JICA, MOT et al., 2004). The bus development projects in Hanoi and Hochiminh city planned also many management measures, for example, public transport management centre, routing improvement, scheduling improvement, transit user incentive and integrated ticket system (HAPC, 1997; Hung, Truong et al., 2001, 2002). The new integrated master plan of Hanoi metropolitan area also recommended a sub-plan of traffic management (see JICA and HAPC, 2006).

Another approach is to implement the of traffic management measures in the annual traffic operation plan of the city transport authorities. This plan consists of short-term traffic control measures, for example provision of some traffic signal control systems, improvement of intersection traffic control, application of one-way traffic, or parking regulation on some urban roads. Other short-term measures are also planned by the city traffic authorities according to daily traffic conditions (e.g. road construction projects or special events).

Finally, traffic management measures are implemented in the daily traffic control activities of traffic police, whose decisions actually react to the specific actual traffic events, for example, closing of road sections and guiding for detour from the accident or congested areas. The main issues of Traffic Management Planning are mentioned in the next section under the analyses about general situation of transport planning in MDCs.

- **Implementation and Maintenance**

In Hanoi and Hochiminh city, the problems in implementation of measures come from a lack of coordination between authorities and operators, except for the traffic management measures in public transport. For other measures, there is almost no real coordination between the providers (transport authority, or urban transport project management units (PMU) and the operators (traffic police). Therefore, conflicts frequently happen, for example, new traffic signals are unconnected to the traffic control centre as planned, new bicycle lanes are used for car parking, and traffic police refuses to enforce the motorcycle lanes.

Another issue is the maintenance service, which was frequently ignored in the planning process. Therefore, the newly installed traffic signal control, the road marking, or even the enforcement forces have been operated for some time after being introduced, and then disappear after some period due to a lack of maintenance.

Issues of planning and implementation of traffic management measures in other MDCs may be different in detail, for example, the big number of transport authorities in Bangkok. However, a lack of coordination among related institutions and lack of maintenance are also parts of issues that lead to an obvious question: Why the number of traffic management measures is so impressive, but their practical effectiveness in solving transport problems is still depressive.

3.3.5. Transport Planning and Implementation

- **Foreign-dependent Transport Planning Concept**

Before the World War II, in some MDCs, the urban transport included a tram-based public transport system and a limited car-based road network that was predominantly designed to serve the colonial city centre only and developed separately from the local transport system mainly utilised by the indigenous population. After the colonial era, the colonial centre was opened for accessibility of all indigenous population. The infrastructure was opened for all transport means, most of which were non-automobile vehicles.

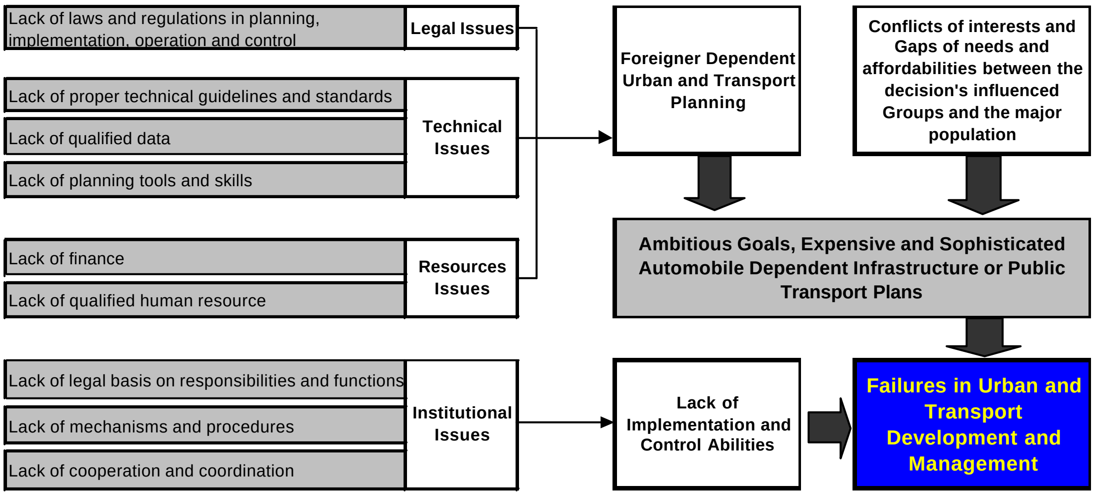


Figure 3-23: Issues in urban transport planning in MDCs

Lack of resources and technical skills led the urban transport infrastructure planning in MDCs to mainly rely on the foreign technical assistance under the process of technology transfer. Most of urban transport plans in the developing cities, in the last 50 years have been carried out by the American, European or Japanese consultants (Dimitriou, 1992).

The issue is that no American, Japanese, or European cities have experienced a motorcycle dependent situation. Therefore, the consultants carried out their works mainly by the car-based planning methods, tools, and experience. The planning solutions were normally focused on road development, except few comprehensive transport planning studies, for example the Bangkok Transport Study 1975 (Rujopakarn, 1999). The foreign defined objectives are far from implementation abilities and political interests of local implementers.

The urban road network was planned and designed for the car traffic only, while the car-based transport system cannot operate safely and efficiently with a mixed traffic flow. Simple conversion from motorcycle or bicycle to passenger car unit has many limitations. Based on the passenger car unit and level of service for car performance, the planned road capacity in the future is usually much larger than the actual need. If the plan were realised, the city would have to spend a huge amount of money, mainly from foreign loans, and large area of land for that expressway, which would depend much more on car use. The social and environmental impacts will also be a very big problem. If the plan is not implemented, the city would have no preparation for meeting the future traffic demand Therefore, the current transport problems would remain, and the new problems would be generated.

- **Ambitious Planning Goals**

One of the most other critical issues should be taken into consideration in the planning process is the conflicts of interests and the big gap of needs and affordability between different groups in the society. In developing countries, the minor group of elites, who are high-income, well-educated or decision-influenced people, can afford and look for very high levels of need in transport. In contrast, the major group of people can afford only basic levels of need, simplest means for mobility and safety. The most fatal error in MDCs is giving the priority to the needs of the elites, who are making plans (professionals), decisions (decision makers, donors), and supplying transport-related products (car manufacturers, road-building contractors). In many cases, the goals are simply defined by foreigners (e.g. donors and consultants). Therefore, the goals are normally too ambitious, strange to local public or too far from the real need and affordability of the society.

- **Technical Issues**

There is a fact that the technical consultants have limited choices in selecting proper planning tools for conducting their studies in the MDCs. So far, no commercial transport planning model or simulation package has been developed for motorcycle-dominated traffic. The reason is that the developed countries have no demand for such motorcycle traffic planning tools, while the MDCs are incapable to develop them. The software's companies will never develop the software that can only sell at a low price in a small-scale market.

Another important issue is a lack of database, data collection and management system. The information exchange mechanism and equipment are also unreliable. In MDCs, most of transports planning studies have to develop their own database. The quality of secondary data is also problematic. The insufficiency of financial and quality human resource is the main barrier for achieving qualified surveys, analyses, and reports.

- **Financial Issues**

Lack of financial resources is the worldwide problem of urban transport, but the situation is more serious in the MDCs. The cities are shortage of money for both investment and maintenance. Most of the investments in the MDCs are expected from the foreign assistant sources, through bilateral or multilateral mechanisms. The assistance always comes with very strict conditions that focus much more on the interest of the donors other than the MDCs themselves. The fund for maintenance comes from the government budget that is always insufficient and needed for many other important sectors. Absence of appropriate fund-raising mechanisms is also a critical question that needs to be answered in MDCs.

- **Human Resource Issues**

The main human resource issue is a lack of knowledge, tools and proper skills. As mentioned above, the conventional solution is to invite foreign consultants. However, the new issue is raised here that the local conditions have not been comprehensively studied and understood by the consultants, who concerned more on the profit than the appropriateness of their design and recommendations. The blind beliefs of the local decision makers on the foreigners' proposals are also problems. In implementation and maintenance, the issues of management and coordination create more head-age than the direct working skills.

- **Institutional Issues**

The functional fragmentation between the urban transport institutions is also an issue in transport planning and implementation. In this model, the provision of services is citywide but different functions are handled by different autonomous local bodies. For instance, in Hanoi, eight organisations are responsible for different functions in the urban transport sector. The case of Bangkok is much more complicated by having twenty-seven organisations that are working in the urban transport sector (PADECO, 2000). In this system, each organisation has a substantial degree of autonomy and it is not very susceptible to influence from subsidiary units in other organisations. The autonomy of organisation has encouraged them to spread horizontally, express their administrative responsibilities across a rage of activities, as well as vertically through a hierarchy of executive units, agencies, institutes, and enterprises. This system seriously suffers from unclear legal basis that leads to overlapping responsibilities and activities between related institutions and their subsidiary units (JICA, MOT et al., 2004). The other issue of functional fragmentation system is a lack of coordination and information exchange between related institutions in the urban transport. The effectiveness of transport performance monitoring and management decisions in the MDCs is limited by inadequate information about the transport situations. There is an urgent need for clear mechanisms and enforced rules of data collection and exchange between transport-related authorities.

3.4. Urban Development Conditions

3.4.1. Political and Socio-economic Conditions

From a global point of view, the political environment in the Asian Pacific Region is stable and peaceful since the end of the Vietnam War in 1975. The conditions of South and Southeast Asia are also peaceful with the end of Vietnamese mission in Cambodia, the end of conflicts between Vietnam and China, and the beginning of Indian-Pakistan talk about their conflicts in Casmir area. The cities are even more peaceful during this era. Therefore, the global political condition does not cause problems for urban transport conditions in the cities.

In a national context, political systems of the Asian developing countries are in a transitional period. Some countries are changing from soviet-style socialistic systems to democratic systems, for example China and Vietnam, and some countries are facing the unstable conditions of immature democracy, for example Thailand, Indonesia, and Philippines. Cities, especially the capital cities, are the centres of political transitional process. The first impact of political changes to transport development is the revision of laws, and regulations, especially the land and properties laws. The second impact is the institutional reform process, which is forced by international agencies after the Asian financial crisis in 1997.

In a global and regional context, peace and stable politics are a basic condition for the economic booms of the countries in the region, beginning with Japan and New Industrial Countries and then now of China, India, Vietnam. The economic growth of countries in this region is leading the world for the last decades (APEC, 2004). Cities are the centres of economic development of the countries in this region. The average growth rate from ten to twenty percent per year allows economic power of these cities to double after five to seven years. The income level of the people there is increasing quickly, their daily activities are exploding, and their travel demand is booming in both frequency and distance.

Many studies recognised that social gaps are increasing, for example, in Hanoi, the difference in income level between poorest and richest groups are about twenty times (JICA and HAPC, 2006). The income gap creates other gaps between groups and influences the development goals of the cities. Closed family relationships in the Asian societies are helpful to reduce the social gaps (e.g. redistribution of income). However, the westernisation and individualisation process is day-by-day destroying this social value.

Another important factor is transport cost, which is changing in two diverse tendencies. The first direction is the reduction of vehicle price in ration with individual income. This direction strongly encourages the explosion of vehicular traffic demand in the cities. The converse direction is the increase of oil-price, which negatively impacts the affordability of individual travellers for vehicle operation cost. However, the change of vehicle technology during the last decades has made vehicle engines more energy efficient. This makes the engine smaller and stronger in capacity, while the rate of energy consumption for one vehicle kilometre is reduced. The social cost of transport was never seriously considered by both government and people in most of cities and countries worldwide. Therefore, the transport price, from the individual viewpoint, becomes cheaper, and people happily buy more vehicle and drive.

Marshall, Banister et al. (1997) said that quick economic growth is the unsupportive condition for the travel reduction effort. However, traffic management has been successfully applied in some Asian cities in satisfying the booming travel demand, for example the Japanese cities, Singapore, or Hong Kong. Therefore, the economic boom may be a challenge for a simple travel reduction approach, but not for a comprehensive traffic management concept.

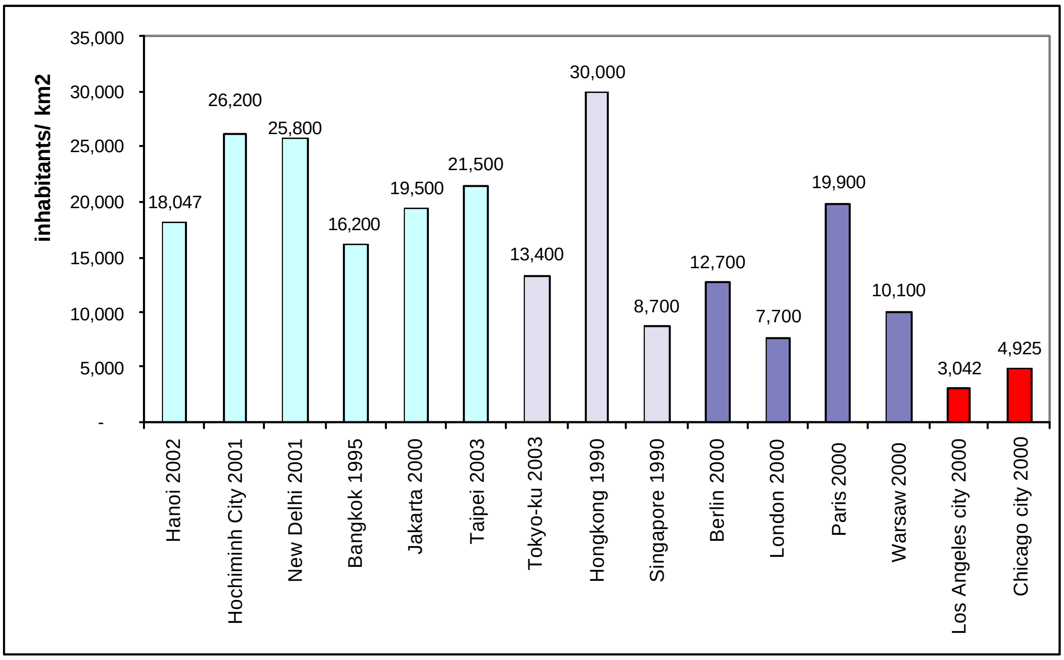
3.4.2. Demographic Conditions

- **Rapid Urbanisation**

The urbanisation rate of the MDCs and other Asian cities are unprecedented. JICA, MOT et al (2004) found that between 1989 and 2001, urban population in Hochiminh city increased from 3.92 millions to 5.3 millions, about 3.8% per year. As centres of economic development, cities are attractive destinations for rural immigrants. Therefore, the population of Hochiminh City in 2001 was about six millions, including approximately 10% unregistered people (Hung, Truong et al., 2002). In another study, Barter (1999) found that the urbanisation rate of Jakarta was 6.5% and that of Bangkok was 6.0% during their golden economic period, 1970 to 1990. In a global comparison, Morichi (2005) found that it took about 80 years for Europe, 42 years for Japan, and only 32 years for Indonesia to increase urban population from 20% to 50%. The main issue of rapid urbanisation is that the cities cannot control their land use development, especially the housing areas. The other issue from urbanisation is travel demand explosion while the infrastructure development is slowly expanding. Therefore, no among MDCs presents as a good example of having balance urban transport condition.

- **High Density Population Urban Areas**

As presented in Figure 3-24, the high-density population is well known and it is one of important backgrounds of the traffic situation in the Asian cities (Barter, 1999; Morichi, 2005), especially in the motorcycle dependent cities.



Note: The figure of New Delhi is only the Central Delhi District; [Data source: see [10]]

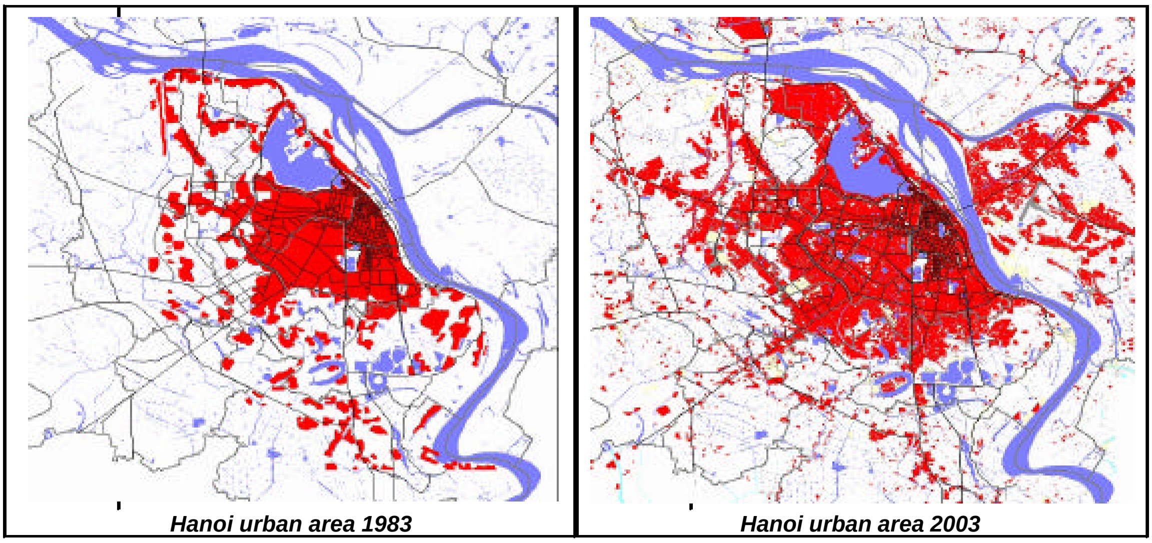
Figure 3-24: Urban population density of selected cities and some references

High-density population is a very big problem for the individual motorised vehicle oriented transport system. In contrast, it is a big advantage for public transport oriented one. In case of Hong Kong, it has the highest population density among the observed cities (see Figure 3-24), but its traffic condition is much better than that in Hochiminh city, Hanoi, Bangkok or Jakarta. In 1990, the modal split public transport in Hong Kong was 89% total passenger vehicular trips, and its PCO was only about 43 car per 1000 inhabitants (Kenworthy, 1995) . The data of American cities give clear image of low urban density in a typical car-dependent city. Bangkok is more congested than the American cities because its population density there is higher, and its road area occupancy is lower (Rujopakarn, 1999). As shown previously, Bangkok's traffic is more congested than that in Hanoi or Hochiminh City, while the population density in Bangkok is lower. Therefore, the high-density population tends to encourage the people to use public transport services, motorcycles, and NMT. In contrast, it must be a big obstacle for the car transport.

3.4.3. Land Use Condition

- **Mono-centric Urban Form**

Most of the big cities in Asian have a mono centric urban form, which means that the city conurbation is expanding continuously outward from the original city centres. Moreover, the city centre contains most of important urban functions, such as business districts, government offices, shopping centres, and in the developing cities, many industries are located in the city centres, as cases of Hanoi and Hochiminh city (see Figure 3-25). This mono-centric urban form creates a big challenge for urban development, management and administration by the scale and quantity of works at once for most of development projects or management functions. The scale of travel demand and its impacts are also a big challenge in development and management of urban transport service.



Note: Before 2000, Northern River bank was not defined as urban area

[Source: unknown scale satellite image (JICA and HAPC, 2006)]

Figure 3-25: Urban form of Hanoi between 1983-2003

- **Mixed Land Use in the City Centre**

Mixed land use pattern is an important background of the motorcycle dependent cities. In his research, Barter (1999) found that most of urban areas in Asia, including Bangkok, Jakarta, Taipei and New Delhi, have mixed land use. According to JICA and HAPC (1997), JICA, MOT et al. (2004) the centres of Hanoi and Hochiminh city also have mixed land use for administrative, commercial, educational and residential facilities. The mixed land uses and high population density of the urban area allow the citizens to fulfil different living purposes within a short radius area around their residential place. This helps people to avoid the long distance trips. The field survey in Hanoi showed that 53.1% of personal trips in Hanoi have a distance of less than 2 kilometres, while the average trip length is only 3.88 kilometres.

- **Trends of Sprawled Development in the New Urbanized Areas**

In most of MDCs, the lack of effective land use planning and controls has resulted in sprawled development extending rapidly in all directions from the city centres (Pucher and Korratyswaroopan, 2004). The unplanned commercial and industrial facilities have been established along the main road. In the deeper layers, the urbanisation has rapidly expanded in the form of low-rise residential development. In the last decade, about 65% of new houses in Hanoi and Hochiminh City had been constructed illegally (JICA, MOT et al., 2004; JICA and HAPC, 2006).

As part of the urban development policies, the sprawled development is supported by the city and national government (Pucher and Korratyswaroopan, 2004). In Vietnam and India, the governments restrict the height of buildings and density of development in the centres and encourage the development of new commercial and residential facilities in the peripheral and suburban areas. Most of the new, urbanised areas were developed without proper infrastructure (roads, water supply, waste water treatment system...) and many of them had been built with only one function.

(a) Ribbon development (JICA, MOT et al., 2004)

(b) unplanned residential area (Waibel, 2003)

Figure 3-26: Images of the urbanisation in Hochiminh City

The most concerned consequence of sprawled development is the extension of trip distance, especially for the trips to and from the new mono function areas. This extension will require for a faster transport mode that would be motorcycles or cars in the case of poor urban transit service.

- **Two-wheeler Accessed Only Blocks**

Many recent residential areas in MDCs can be accessed only by two-wheelers or pedestrians. This uniqueness is a consequence of the lack of consideration on the integration between transport and land use planning, incapability of land-use control and the explosion of motorcycle use. The motorcycles allow people to easily access the areas located far from the main road by simple and narrow alleys. Therefore, the cities were expanding in the oil-stain model deeper and deeper from the main road without consideration and need of the car-based distributor roads. About 50% of the Hanoians are living in the blocks that are connected by the less than 3-meter-width alleys. The households in these blocks have higher MCOs than in others.

Some experts believe that the only solution for this situation is to expand the alleys in order to have four-wheel access condition (Rujopakarn, 1999). In contrast, others found that the alley networks are heaven for pleasant walking, cycling and tricycle riding (Barter, 1999). The above discussions show that the two-wheeler accessed only block in MDCs has two controversial impacts. First, it reduces the accessibility to the blocks, especially for emergency services that are based on four-wheelers. On the other hand, it exists as a natural barrier to avoid the growth of car ownership, car use and its negative impacts, and to encourage the residents to travel by two-wheelers and NMT.

3.4.4. Trends of Urban Transport Situation and Problems

- **Urban Development Trend in MDCs**

Politics

From the global context, the geo-political conditions in the Asia-Pacific region will continue to be stable. Although there are risks of warfare conflicts in the region, for example, the conflicts between North Korea and the USA, between China and Taiwan, India and Pakistan etc, the trend is that conflicts between countries in the region will be solved by diplomatic solutions.

Socio-Economic and Culture

The market economy is continually applied and strengthened in all Asia Pacific countries. In each country, the economy will continue to grow at a high rate for the country as a whole and at the cities. Income of people is increasing, but the gap between the rich and the poor is expanding, too. The income discrepancy and the westernisation process will create new social and cultural values, and new conflicts between different social and cultural groups in the cities. In general, maturity of people in transport behaviours is increasing.

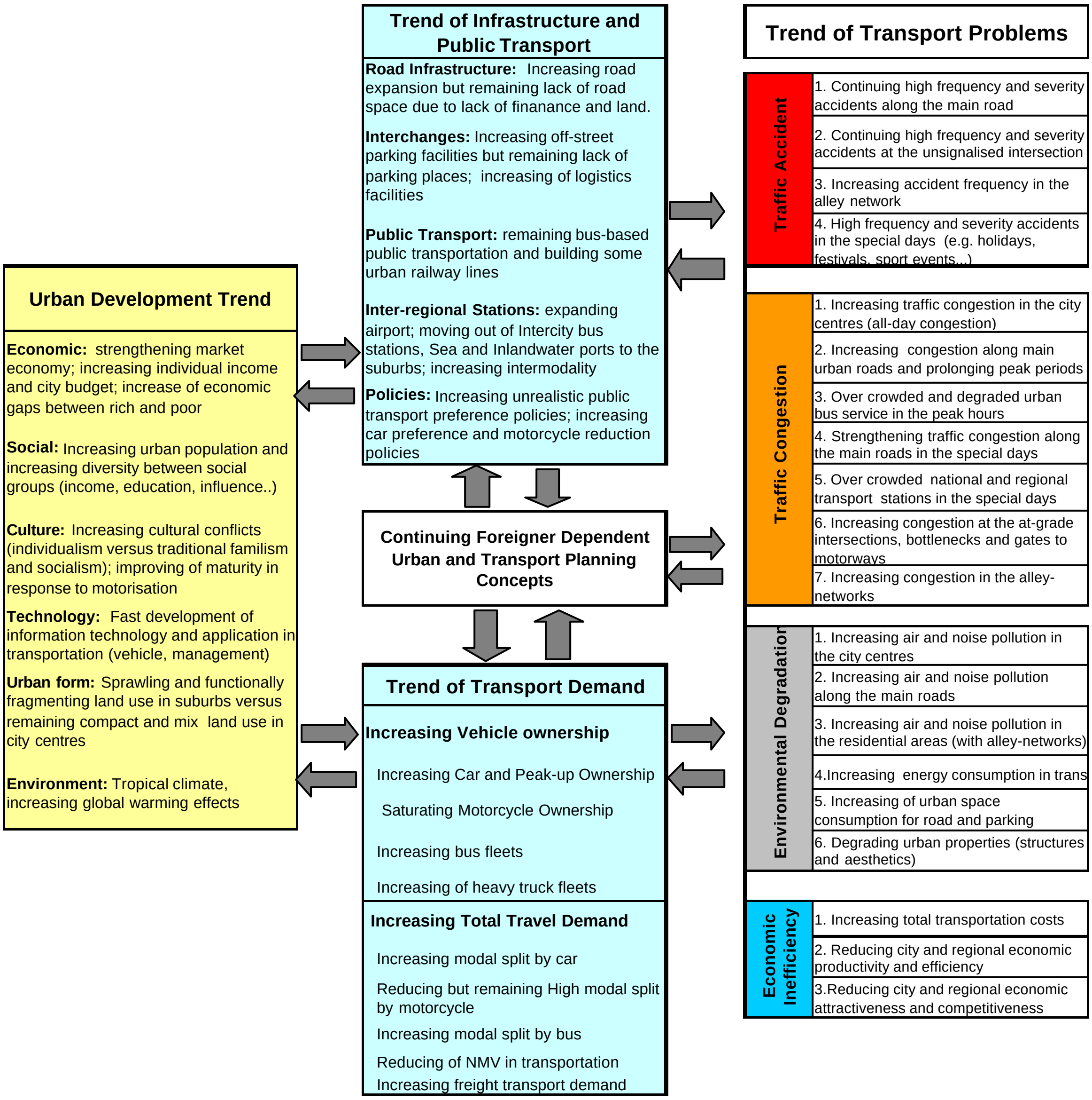


Figure 3-27: Overview of urban and transport development trends in MDCs

Technology

Computer science and information technology will be applied widespread in all aspects of transport sector, especially in transport planning and in traffic management practices.

Urban Form

Although planning goals will focus on multi-centric urban form, the mono-centric urban form will continue for long time in MDCs. The population and activities will remain concentrated and mixed in centres of cities while the new sub-urban areas will be sprawled to adapt for car-based traffic.

Natural Environment

The tropical climate is an unchanged factor in the future while the effects of global warming are difficult to forecast.

- **Transport Development Trends**

Trend of Infrastructure and Public Transport

Although the development of urban roads will continue to be prioritised, the road area and parking facilities in MDCs will be still insufficient due to a lack of finance and land. The logistic facilities will develop quickly to serve economic development of the cities. The rail transit oriented transport system will be strongly recommended in planning, but bus service will continue to play a key role in public transport. Some rail transit lines may be developed but they will still play a minor role in public transport. To serve the centres of country economic development, the inter-regional and international transport stations in MDCs will be expanded. The major railway, roadway and inland-waterway transport stations will be moved from the old city centres to the new sub-urban areas. Unrealistic rail transit oriented policies will continue to exist only in papers, while car-oriented policies will be implemented.

Trend of Transport Demand

In general, motorised vehicle ownerships will increase for all types, except the motorcycle. The lobbies of auto manufacturers via WTO and ODA conditions will break all import tariff barriers for cars, pickups, buses and trucks. The reduction of vehicle price and increase of income, will create travel demand explosion in both regional and urban transport. Modal split of car trip will increase strongly. There will be some reduction in motorcycle trip but its modal split will remain high. Public transport demand will also rocket in both urban and regional transport. Non-motorised transport will be continually reduced in urban areas.

- **Trend of Urban and Transport planning**

The dependence on foreign Official Development Aid (ODA) in urban and transport infrastructure development will remain. Therefore, foreign planning concepts will continue to dominate without any meaningful resistance from local experts and authorities.

- **Trend of Transport Problems**

Traffic Accident

The frequency and severity of accidents will reduce in the centres due to traffic congestion, improvement of traffic management and maturity of road users. On the other side, frequency and severity of traffic accidents will increase on arterials, sub-urban roads and even in two-wheeler accessed only blocks. Accidents will increase in frequency and severity on special days, such as holidays, examination days, days of sport and cultural events etc.

Traffic Congestion

There is no doubt about the increase of traffic congestion in almost every where in the cities, from the old centres, arterials, main stations to the new development sub-urban areas. The opens of new urban express way will not reduce the city congestion due to its attractiveness for travelling. The construction of grade intersections at the gates of city centres will bring congestion to the heart of cities. Period of congestion will be prolonged to all day at the city centres and along major arterials. Public transport services will be seriously crowded during peak hours and service quality will be degraded.

Environmental Degradation

The city centres will be more polluted by transport sources in spite of the reduction of other pollution sources, e.g. construction and open fire coals for cooking. The residential areas will be more polluted by both noise and air pollution. Transport system will be more oil-dependent, and the energy consumption in transport will increase in spite of the adoption of efficient engines and alternative fuels. There is no doubt for the increase of road and parking areas and the reduction of green fields. The urban properties (structures and aesthetics) will be attached by expansions of roads and interchanges.

Economic Inefficiency

The current low transports cost will not long lasting. The oil price will force most of governments to remove their gasoline subsidy. The transport cost will increase for individuals and economy. Traffic congestion will also contribute to the increase of transport costs. Traffic accidents, congestions and pollutions will significantly destroy the economic attractiveness of the city and region. On the other hand, any management effort for reducing accident, congestion and environmental pollution of motorised vehicles will invite additional costs.

3.5. Conclusions

The main findings of this chapter are the definition of motorcycle dependence, the traffic problems, causes of the problems, and opportunities and challenges of urban transport in the motorcycle dependent cities.

- **Motorcycle Dependence**

The motorcycle dependence of city is defined by examining three groups of indicators: *vehicle ownership*, *availability of transport alternatives*, *use of motorcycle*. The results indicate that in a typical motorcycle dependent city the urban traffic has the following key features:

- High motorcycle ownership, of higher than 350 MCs/1000 inhabitants,
- Lack of public transport alternatives (less than 1 buses /1000 inhabitants) and incompetent NMT when compared with the motorcycle,
- Very high share of motorcycle in the traffic flow (more than 50%)
- High modal split of motorcycle (more than 40%) and extremely low modal split of public transport (less than 20%) while the percentage of NMT trips is still significant (about 20 to 40%).

The analyses proved that Vietnamese cities, represented by Hanoi and Hochiminh city, are in the situation of *captive motorcycle dependent*. Those cities have extremely high MCO, lack of public transport service and discouraging policies for non-motorised alternatives. That situation is presented by an image of motorcycle dominated traffic flow. Taipei represents a high-income city and with medium motorcycle dependence. The uses of private cars and public transport in Taipei are quite balanced. Bangkok represented as a medium-income city and with medium motorcycle dependence. However, high level of car use creates serious traffic congestion in this city, which experts called “traffic disaster” or “Bangkok symptom”. Jakarta and New Delhi would become car dependent cities soon, if they could not control the car use.

- **Problems of the Urban Transport in MDCs**

Traffic Accidents

Traffic accident is the most serious traffic problem of the MDCs in comparison with other types of city. The growth of motorcycle ownership pulls up the accident fatality index. Severe traffic accidents occur mainly outside the city centres, main arterials and on the ring road. However, the lower severity traffic accidents in the urban area also caused many injuries, properties damages, and the traffic congestion at the sites and the related roads. Accidents occur more frequently in the night time. The relative good traffic safety in Taipei reveals the ability to still have safe traffic with high motorcycle ownership.

Traffic Congestion

In the captive motorcycle dependent cities, traffic congestion is currently not as serious as other developing Asian cities (e.g. Bangkok). Traffic congestion in MDCs occurs during the peak periods, along main commuting corridors and normally begins at intersections and bottlenecks. During peak-periods, public transport services on the main corridors are also congested. The average travel speed during peak hour is reasonable, at about twenty to twenty five kilometres per hour for all motorised vehicles. Average travel time is relatively short compared with many other cities over the world. However, traffic congestion will definitely increase in the near future by increasing use of private cars.

Environmental Pollution

Currently, urban transport is not presented as the most important source of air pollution in Hanoi and Hochiminh City, where the motorcycle fleet comprises mainly four-stroke engine vehicles. In contrast, the motorcycle use creates serious air pollution in New Delhi, Bangkok, and Jakarta, where number two-stroke engine motorcycles is major. However, the level of pollution was serious at the traffic congestion sites in all five cities. Both types of vehicles create high level of noise pollution in all five cities.

Data significantly indicate the serious noise level in both day- and nigh-time along the road networks in above five cities. Regarding environmental pollution, Taipei is no longer presented as a positive example. About ninety percents of air pollution in Taipei are emitted from transport sources.

- **Urban Transport Issues**

Travel Demand and Behaviours

The travel demand in MDCs is extremely high due to high population density and high availability of motorcycles. The flexibility and space efficiency of motorcycle and the existence of high NMT use are the main reasons of high mobility level and low air pollution. In contrast, the increase of car use and the low capacity public transport services are the main threats for traffic congestion and pollution in the near future. Immaturity of road users in response to the motorisation, lack of traffic operation and control measures, weak enforcements are addressed as the main causes of traffic accidents in MDCs.

Road Infrastructure

Lacks of road and parking facilities are presenting the image of urban transport infrastructure in MDCs. Absence of road hierarchy in transport planning concept, insufficient finance and land for roads and parking facilities, no consideration of motorcycles and NMT are the manifestations of incomprehensive planning process and incapability in implementation.

Traffic Management

The study found that many traffic management measures have been taken in urban transport system in MDCs. However, the traffic management measures are planned and implemented by chance, either from some demonstration projects, or by reactions of traffic police and transport authorities. A comprehensive Traffic Management Plan is presented, but mainly in documents, probably for demonstrating consultants' knowledge. Therefore, the daily traffic in MDCs still encounters inadequate traffic operation and control, for example, confused road signs, road markings, and primitive traffic control measures at the intersections.

Transport Planning and Implementation

Lack of resources and technical skills leads the urban and transport development planning in MDCs to rely on foreign technical assistance. Urban and transport plans in MDCs have been carried out by the foreign consultants, who conducted such plans by their home planning methods, tools and experiences.

The planning goals are selected by and for a minor elite group in the society other than by and for public. In many cases, goals are defined and selected by foreign consultants. Therefore, goals of plans are normally either unrealistic or donor driven.

Technical consultants have limited choices in selecting proper technical guidelines and planning tools for conducting their studies in the MDCs. The other technical issue is lack of traffic database, data collection and management systems.

Lack of financial resources is well known in MDCs, and realised in a lack of money for both investment and maintenance. Other issues include lack of knowledge, tools and proper human resources for all functions in transport sectors.

The functional fragmentation structure of urban transport institutions is a critical issue in transport planning and implementation. This system seriously suffers from unclear legal basis, overlapping responsibilities, and lack of coordination between related institutions.

- **Urban Development Issues**

Politic and Socio-economic

In a general context of Asia Pacific region, the political environment is peaceful and not raising critical effect on urban transport. The economic growth of the countries and cities are impressive and continuing for decades. The economic success is the main cause of travel demand explosion in MDCs.

Demography

Most of MDCs are rapid urbanising in all directions. Therefore, the cities are facing great difficulties in controlling their land use development. Another issue of urbanisation is travel demand explosion while the infrastructure development is slowly expanding. In contrast, the high population density creates high traffic demand or a good potential market for public transport. The individual motorised transport demand can be optimally afforded mainly by motorcycles, while private car use can be minimized.

Land Use Condition

The mono centric urban form of cities creates a big challenge for urban development, management and administration by the scale and quantity of works at once for most of development projects or management functions.

On the one hand, the high density and mixed land use in the city centres is a good advantage for motorcycle dependent cities to reduce the number of trips, and to promote public transport and non-motorised transport. On the other hand, the trend of sprawled urbanisation leads to the extension of the trip distances and urges people to depend more on motorised transport modes.

The unique two-wheeler accessed only block has two controversial sides. First, it reduces the accessibility of the areas, especially for emergency services. Secondly, it is a natural barrier to avoid the development of car ownership and car use and to encourage the residents to travel by alternative modes.

- **Opportunities and Challenges**

Opportunities

Although differences still exist, the awareness of people and governments about interdependencies between developed and developing countries has been raised during the last decades and will further improve. The trend will refine and improve the purposes, quantity, and quality of technical assistances from developed countries to developing countries. The global information exchanges will allow the MDCs to learn from international failures and successes in urban transport development and management. The globalisation and integration also allow the MDCs to access the sophisticated tools for planning and managing the urban transport system. Moreover, they have also opportunities to develop their own human resources and technical tools that fit the unique situation of the MDCs.

The constraints of finance and urban land will force the governments and investors to search for least costly transport development and management solutions. As discussed in Chapter Two, low costs and variation in technologies make traffic management solutions become the most suitable way to deal with the problems in transport system of MDCs. Moreover, the modularity and flexibility of traffic management measures allow them to work well in the functional fragmentation of the urban transport institutions.

In terms of urbanisation, the rapid changes of urban form and land use will not be supportive for long-term planning projects and then it requires the shorter term and more flexible solutions as traffic management measures. The opportunity is also addressed from the background of MDCs with high-density population and mixed land use urban centres. These are very good conditions to develop a low cost sustainable urban transport, including public transport and non-motorized transport services, in the future. The presence of motorcycles in MDCs as the main transport mode is also an opportunity for MDCs in finding a very good alternative to the private car for most of the trips within urban areas.

Challenges

The explosion of car use is the most serious threat for the future of the urban transport in MDCs. Although the economic boom is impressive, the lacks of financial and resources will continue to prevent the MDCs from providing enough roads and parking facilities for car dependent traffic. Therefore, traffic congestion and pollution will be much more serious in these cities. On the other hand, the car use will lead the society to be more dependent on oil and to consume products mostly imported from the other countries and become scarcer in the future. The sprawled urbanisation is also a big threat for MDCs. This will make the distances of the essential daily trips become longer and encourage people to use individual motorised transport modes for their daily travel. Consequently, the increase of transport costs in finance and time will reduce the economic attractiveness of MDCs.

Foreign assistance and technology transfers from a developed city contain not only opportunities, as discussed above, but also threats. The planning concepts will continue to be foreigner dependent and the planning goals will still be as ambitious as today. The assistance is always provided under very strict conditions that focus seriously on the interests of the donors other than the MDCs themselves. The planning projects will first provide jobs for foreign contractors, for the key donor countries, and then to initiate a new market for foreign industries, for example for car manufacturers or rail transit producers. Instead of the Catholic Fathers, technical consultants would be considered as the pioneers for the new colonial missions. To avoid such threats, it is useful to reprint here the warning of a German professor “I would like to warn my colleagues from highly industrialised countries to give too precise recommendations from their own point of knowledge and experience to developing countries. Especially consultants from abroad should bear this in mind” (Retzko, 2005).

4. A Strategic Policy Framework for Traffic Management in MDCs

The urban transport problem analysis of MDCs shows that lack of proper strategic policy framework (SPF) is the root problem of planning and implementation of urban and transport projects in MDCs. This indicates by absence of natural links between urban development goals, strategic objectives of transport development and the lower-level objectives of transport modes, investment projects and management activities. Therefore, the focus of this chapter is to formulate a strategic policy framework for traffic management, which shows a clear image of the hierarchical relationships from a specific objective of traffic management measures up to the top vision for future development of a typical MDC. The first section presents a strategic vision and urban development goals for a MDC. From the urban development goals, the subsequent strategic objectives for future development of urban transport system will derive. The next section presents the subsequent development objectives of different transport modes. Finally, the subsequent management objectives derive from those modal development objectives. The emphasis of this chapter is that the SPF here is formulated based on the consideration of benefits of overall society within a certain urban area. Therefore, contents of this SPF may be different from those of transport operators, logistics companies or even of transport authorities, those central benefits are specifically for one person or a group of persons only.

4.1. A Vision for Future Development of MDCs

For a live entity, the vision for future development is the final achievement of a process, which includes efforts of all elements of the entity under impacts of interactions between this entity and its external environment.

The strategic vision for a community, city, country, or region is the sustainable development that was defined by the World Commission on Environment and Development (Brundtland Commission) with serious concerns about differences in three major functions (*economic*, *socio-culture*, and *natural environment*) between communities, cities, countries and regions in the world. The sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). The sustainable development definition is widely applied in defining strategic vision of a city, as seen in many literatures.

In a universal context, Mumford (1961) concluded his famous book "the City in History" by stating that ***"the final mission of the city is to further man's conscious participation in the cosmic and historic process".*** With the same philosophy and by simpler wording, Albert Speer and Partner (1993) states the vision of a German city (e.g. Frankfurt) is *"improving quality of life"* by: (i) Improving quality of residential environment, and (ii) Improving habitat quality for the economy.

Although no one plans a ***real final end*** for a living city, planners or decision makers may need a picture that describes generally the state of the city at a certain time in the future for making recommendations or decisions for a time-bound plan or action. For that need, one may refer to the Livingstone's statement about the vision of London. This presented three key functions of London's future as "*to develop London as an exemplary sustainable world* *city based on*: (i) Strong and diverse economic growth, (ii) Social exclusivity to allow all Londoners to share London's future success, and (iii) Fundamental improvement in environmental management and use of resources" (Greater London Authority, 2001).

In developing cities, the strategic vision is normally ignored even in many long term planning studies, no vision or strategic policy framework that has been addressed. Only specific objectives for the study works have been defined, while the plan or projects are not driven by a strategic vision.

For example, the statements could be *"the objectives of Bus Sector Reform Project were to identify ways of reducing subsidies*" (Bangkok Bus Sector Reform Project - GTZ, 2003) or *"to formulate a Master Plan for strategic urban transportation for Hanoi city"* (Master Plan of Urban Transport for Hanoi City in Vietnam -JICA and HAPC, 1997). Looking over the reports, one could not see any link between those specific objectives and the strategic vision for future of the cities, e.g. Bangkok or Hanoi. Recently, the Comprehensive Urban Development Program in Hanoi Capital City states a vision on top of its strategic policy frame work as *"to develop Hanoi in an economically, culturally, environmentally, and politically manner, making sure that the city's beauty, resources and amenities will be sustained for generations to come"* (JICA and HAPC, 2006). That statement looks better than the other two, but the final goal indicates simply only desired situation of one aspect, *environment*, other functions are not presented.

In a general consideration for any urban area, including the motorcycle dependent cities, the statement of Vuchic (1999) can be recommended. This professor expresses that a vision for an urban area, which are aiming toward a ***liveable city****,* should include the following characteristics: ***human-oriented and environmental friendly***, ***economically viable and efficient***, ***socially compatible***. In a recent publication, Retzko (2005) had recommended two groups of ***organisational*** and ***physical transport measures*** for liveable cities.

4.2. Strategic Goals of Urban Transport System

In a metabolism model of human settlements, to achieve a sustainable transport system is one of the three major development goals of a liveable city (Newman and Kenworthy, 1999). The other two goals are to achieve a strong and compact economy and a rich, compact and harmonise culture. This study focuses on that top development goal of transport system, which will be further descended into lower level goals and objectives to continue the way formulating a strategic vision for urban transport in MDCs.

Current guidelines and textbooks in transport planning and development recommend the transport planners and policy makers consider a catalogue of nine to ten different goals. For example, the Guidelines for Developing Urban Transport Strategies proposed a possible set of goals includes: Economic Efficiency, Environmental Protection, Safety, Accessibility, Sustainability, Economic Regeneration, Social Equity, Financial feasibility, Practicability (IHT, 1996; May, 1997). This goals set is simply rich and widely applied in British cities but it may confuse planners and decision makers by overlapping between goals, for instance, if a transport project can achieve *economic efficiency*, *environmental frie*ndly and *social equity*, thus this project is already *sustainability*. Some other goals are not at strategic level, for exam *feasibility* or *practicability*, but at the implementation level.

Cambridge Systematic Inc. (2000) and Meyer and Miller (2001) recommended a set of eight goals for an urban transport system as: accessibility, mobility, economic development, quality of life, environment and resource consumption, safety, operating efficiency, system preservation. This set is also rich and may be widely applied in American cities but planners and decision makers would be confused between what are defined as the goals for a city as a whole (for example *accessibility* or *quality of life*) and what one can expect from the transport system (e.g. *traffic safety*, *mobility*, *energy saving*).

Although one may not be so happy with its vision for the future of city, but, the goals set for an urban transport system defined by Albert Speer and Partner (1993). This definition presents an image of a future urban transport system, in which all movement demands of people and goods will be satisfied in a safe, environmental sustainable and economical manner, which will be the propulsion for economic development of the region:

Goal 1: To ensure the mobility of all transport demands in the coverage area,

Goal 2: To ensure traffic safety of all traffic movements, which are performed by the concerned transport facilities and services,

Goal 3: To protect natural resources and reduce environmental impacts in the coverage area and surrounding,

Goal 4: To improve the economy of the coverage area, the city and region

These goals are suitable not only for a developed city, like Frankfurt, but they can be properly applied in any city, including the MDCs. Therefore, in this study, these goals are invited for further works in developing a traffic management concept and its contents for the MDCs.

4.3. Strategic Objectives of Urban Transport System in MDCs

4.3.1. Introduction

The set of strategic goals of urban transport system are further broken down into more specific and measurable objectives. At this point, one should be strongly aware that between the goals themselves there are interrelations. For example, if the level of mobility were low, the city and region would not be attractive in economic development. The same kinds of relations are defined between safety and mobility, between environmental friendly and economic development and so on. The interrelations also exist and can be defined between different objectives under each goal and between objectives of different goals. Although the interrelations are significant, the independent presentations of goals and objectives are necessary in order to understand the contents of the societal expectation from an urban transport system, mode or certain project.

4.3.2. Goal 1: To Ensure Mobility for All Transport Demands

- **Objective 1.1: to ensure equality in using public transport properties for mobility**

This objective emphasises on the equal right and opportunity of using transport area (road and interchange points) for mobility of firstly major social group and all others, for example, intersection control program should consider traffic flow of motorcycles, buses, bicycles, pedestrians, not only private cars. Although the direct criteria can be used to measure this objective, for example total square metre * hour for certain mode during critical period (peak hours) at critical location (e.g. intersection), indirect criteria, for example total social costs per person*kilometre or subsidy per person*kilometre, are more favourable in practice.

- **Objective 1.2: To increase number of modal choices**

This objective focuses on provision of public transport services and safe traffic environment for low-cost transport modes (NMV and motorcycle), which will increase the possibility to meet the transport demand of the major social group and others. This objective can be measured by the number of modal choices per trip for different purposes.

- **Objective 1.3: To increase productivity and efficiency of transport supply**

This objective emphasises the maximisation of the productivity and efficiency of existing urban roads, parking facilities, public transport infrastructure and vehicles by improving control and operation mechanisms. Criteria for measuring this objective are varied in productive forms, for example (passenger * kilometres) per (lane kilometre*hour), passenger kilometres per seat*kilometre (in public transport) service, or passenger*kilometres per litre of fuel etc.

- **Objective 1.4: To increase capacity of transport supply**

This objective focuses on the provision of new supply capacity or to enable an idling capacity in term of new urban road, parking facilities for individual transport modes of major social group and all others, public transport infrastructures and high capacity vehicles, additional space for bicycle and pedestrians. This objective is measured by conventional criteria, for instance, road length or road area, or number of buses or length of urban rail network.

4.3.3. Goal 2: To Ensure Traffic Safety of All Traffic Movements

- **Objective 2.1: To reduce frequency of traffic accidents**

This objective focuses on the reduction of possibility and occurrence of traffic accidents in all transport forms and modes, especially of the motorcycle in MDCs. The criteria to measure this objective are accident numbers, accident density (e.g. per kilometre of road length) or accident rate (e.g. per one hundred thousands of population), etc.

- **Objective 2.2: To reduce severity of traffic accidents**

This objective focuses on increasing survivability of people, vehicle, and reducing extent of damage to facilities and environment in cases of accidents. As the main participants in accidents in MDCs, the motorcyclists must be better protected. The criteria to measure this objective are number of fatalities per year, fatality rates, total costs per accidents, etc.

4.3.4. Goal 3: To Protect Natural Resources and Environment

- **Objective 3.1: To reduce air pollution from transport**

This objective focuses on reducing the total quantity and local discharge rates of air pollution from construction (manufacture) operation, maintenance and termination of vehicles and infrastructure facilities. In MDCs, the reduction of air pollution from motorcycles and dust from road's construction and rehabilitation activities is important. The criteria to measure this objective can be varied, for example, concentration of certain pollution during certain period (peak hours, day time, night time or all daylong), or quantity of pollution per person or ton kilometre, per vehicle kilometre or per capacity unit kilometre.

- **Objective 3.2: To reduce noise pollution from transport**

This objective focuses on reducing noise generated from construction (manufacture) operation, maintenance, and termination of vehicles and infrastructure facilities. In MDCs, reduction of noise from motorcycles, old buses, and trucks is the most important task. The criteria to measure this objective are normally the average noise level at certain time point at representative observed locations in the targeted area (road side points, or construction sites) or average generated noise from tail pipe of a certain type of vehicle.

- **Objective 3.3: To reduce use of energy in transport**

This objective focuses on saving energy in general and fossil fuels in particular from construction (manufacture) operation, maintenance, and termination of vehicles and infrastructure facilities. In MDCs, trying to avoid the future car dependence is the most important task in order to achieve this objective. The criteria to measure this objective are varied, for example, average kilowatts of power per person kilometre, per vehicle kilometre, quantity of gasoline or diesel per person kilometre or per vehicle seat kilometre.

- **Objective 3.4: To reduce dedication of urban space for transport facilities**

In MDCs, this objective focuses on optimising use of urban space in general and eliminating overuses and redundancies in using urban space for transport infrastructure. The criteria to measure this objective are varied, for example, percentage of total road and interchange spaces in total urban area, ratio of total occupied square kilometres * hours over total available square kilometres * hours of roads or parking facilities.

4.3.5. Goal 4: To Improve Economy of the City and Region

- **Objective 4.1: To reduce total cost of transport and logistic services**

This objective focuses on reducing the consumption of urban space, energy, and other resources and minimising the total of waste output from transport and logistic services. The criteria to measure this objective are varied, for example total cost per person-kilometre, total cost per ton kilometre, or total transport cost per hour of activities that generate the trips etc.

- **Objective 4.2: To increase economic productivity and efficiency**

This objective focuses on reducing time and cost consumption in transporting people and goods on an urban and regional scale. The criteria to measures this objective are varied, for example average time for transport per working hour, per ton of materials or per product unit

- **Objective 4.3: To improve economic attractiveness of the city and region**

This objective focuses on increasing the number of jobs, investment, and income, which are created directly or indirectly by urban transport system. This objective for transport may not be in high priority of MDCs at this moment when the economy is growing fast and even over management capacity, but it should be considered for a long-term vision.

In general, this set of goals and objectives can be applied for any plan, project and activity, which is either to develop a transport infrastructure, to provide a public transport service, or to manage traffic performance at different scale, from overall urban transport system to a specific supply unit. This can be applied for different types of cities, which are in different level of development and in different urban and transport situation. However, priority orders of goals and objectives can be different according to specific conditions of targeted areas.

4.4. Urban Transport Development Scenarios

4.4.1. Overview

Based on a strategic vision, one can start thinking of the future scenarios of urban transport system, in which provision and performance of different transport modes and their interconnection are defined. In a comprehensive study about urban transport and land use evolution in Asian cities, Barter (1999) discovered that although the cities are developing on different paths, three different pictures of urban transport and land use are drawn for Asian cities: *automobile city*, *modern transit city* and *traffic saturated city*.

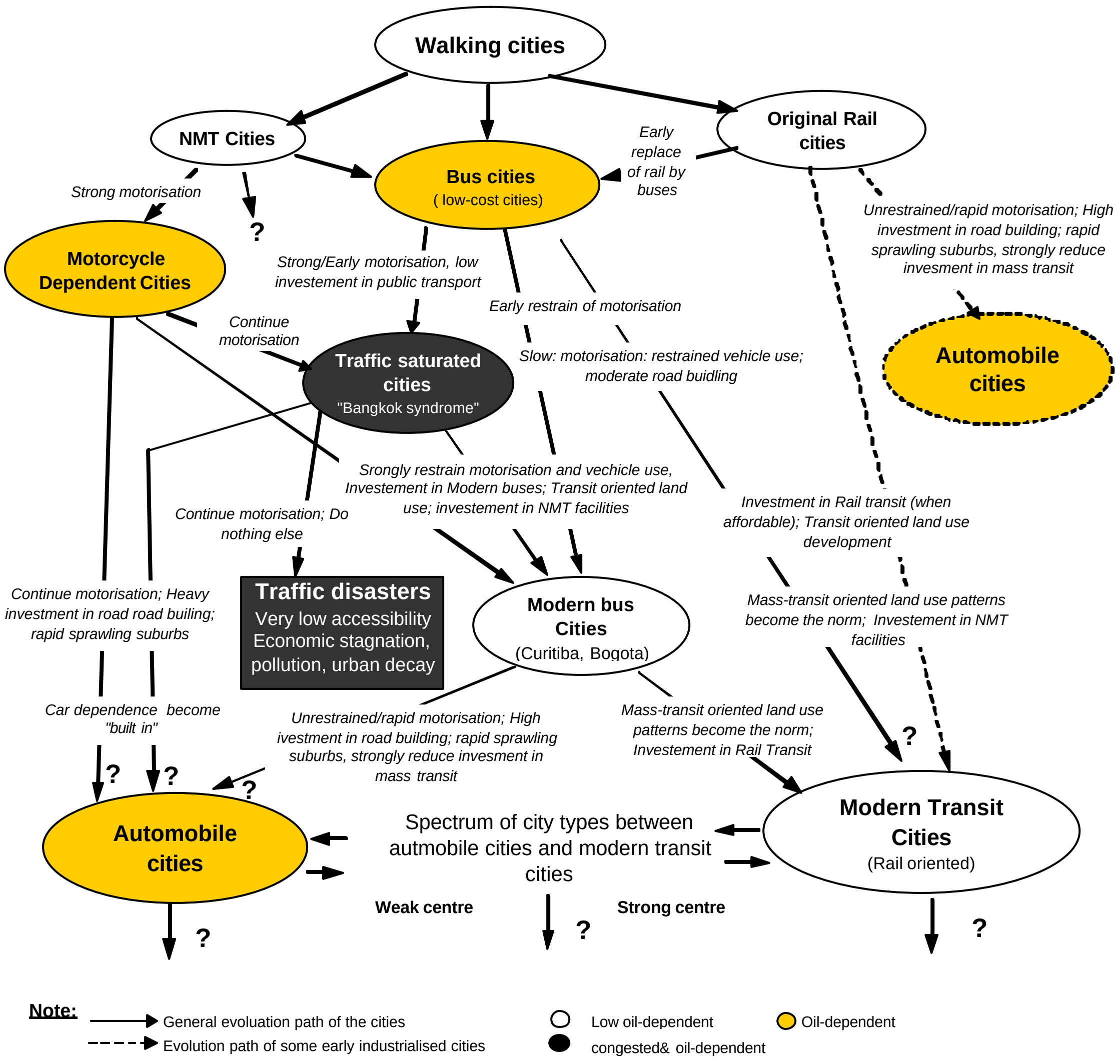


Figure 4-1: Generic model of urban transport and land use evolution

From that finding, the author drew two pictures of models of urban transport and land use evolution in Asian cities. In the second picture for developing cities, he indicated the state of motorcycle city defined in this study as motorcycle dependent cities. The picture in Figure 4-1 is a combined version of two Barter's models, in which main alternatives of development paths of urban transport and land use in motorcycle dependent cities are presented in a general context, also including other types of cities. In this picture, the development paths lead MDCs to one of three future scenarios, a traffic saturated city, an automobile city, or a transit city.

4.4.2. Traffic Saturated City

This would be the first scenario for MDCs resulted by the natural development trend of MDCs, on which the cities will simply continue their explosive motorisation process with lack of road and parking facilities and uncontrollable urbanisation process. This stage may not be the end if the cities would then accept a shock therapy to go to either automobile city or transit city. Otherwise, the urban transport system of cities would simply turn to a traffic disaster if there would be no huge expenditure. The conclusion here is that this scenario can be and should be avoided. MDCs should look for other ways to go

4.4.3. Automobile City

This would be second choice for future of MDCs, with which the cities would concentrate all transport investment on construction of new highway and parking facilities while to continue the motorization process freely. The American and Australian cities are representatives for this type of city, where the population and activity densities are very low and transport costs (investment and operation) are very high and paid by a high income levels of both, individuals and economy (Newman and Kenworthy, 1999; Kenworthy, 2003). Most of American and Australian people are proud of their interstate highway system and also they are daily frustrating with traffic congestion, shocking ands stress with new growing oil price, and finally, they are facing the finish of fossil oil. Therefore, no such title of world liveable city has been conferred to any automobile dependent city, so far. Although, this path is a solution but not the last one, and MDCs should look for other solutions.

4.4.4. Transit City

As presented in Figure 4-1, this is the last option that is provided so far in the history of urban and transport development. In the history, many cities in Europe and Japan succeeded in developing a modern transit city, from either a bus city or original rail cities. This process has been continued for a century, as the case of Japanese city. At the current level of MDCs, there are two stages on the way to a modern transit city. The first one is going to a bus-transit city, as the example of Curitiba (Brazil), Hong Kong, or Singapore during the period from 1975 to 1995. During that period, the cities are still at a medium level of economic development.

The next stage is to develop further the heavy urban mass transit systems. Taipei and other Taiwanese cities are following this two stage of development from the situation of motorcycle dependent cities since 1990 (PADECO, 2000). Recently, the transport development plan of MDCs also selected this direction, for example the seventh and eighth National Socio-Economic Development Plans of Thailand (Rujopakarn, 2003), or urban and transport plans of Hanoi and Hochiminh city in Vietnam (JICA, MOT et al., 2004; JICA and HAPC, 2006).

The most important emphasis here is that all of the world's liveable cities are modern transit cities (Newman and Kenworthy, 1999; Vuchic, 1999). The second emphasis is, all high-density urban areas worldwide use mass transit is the major transport solution. The third reason is the weak point of mass transit service opens a big market for other environmental friendly transport mode, walking and cycling (including motorcycle). During the transition period, motorcycle is the most economical solution to serve motorised travel demand and to avoid huge investment on roads and parking facilities, as for private car. Therefore, conclusions for a future scenario and development path are as follows:

> **The desirable scenario for future development of urban transport and land use in MDCs is the modern transit city.**
>
> **The mentioned two stages of development path are also suitable for current situation of MDCs.**

4.5. Objectives of Traffic Management in MDCs

4.5.1. Introduction

This sub-chapter first focuses on defining desired impacts of traffic management measures on different transport modes, which are parts of current transport system in MDCs. The second part presents the contents of effectiveness and applicability, which are the main objectives in implementation of traffic management measures.

4.5.2. Modal Objectives of Traffic Management in MDCs

- **Overview**

As discussed in Chapter Two, traffic management measures in MDCs are categorised by transport modes, which are defined as components of urban transport system. Therefore, the objectives of traffic management measures in MDCs are manifested by the impacts on transport modes. Figure 4-2 provides a general description about the interactions between transport modes and strategic goals and objectives of urban transport system in MDCs. These would be the impacts on the strategic objectives if transport development and management efforts focus on prioritising and/or improving certain transport modes. The interactions are the basis for defining modal objectives of traffic management in MDCs.

- **Public Transport Prioritisation**

Figure 4-2 again emphasises the selection of transit city as future development scenario of urban transport system in MDCs. Among urban transport modes, public transport proves to be the best transport mode in the aspects of mobility, safety, and economic. Only in the aspect of environmental friendly, public transport ranks at second, after non-motorised transport modes. Studies, reports and books emphasise that the high modal share of public transport modes in the total passenger transport demand is one of the most important indicators of a sustainable transport system (Buchanan, 1963; Morlock, 1976; Newman and Kenworthy, 1999; Vuchic, 1999). Therefore, traffic management measures should encourage travellers to use public transport services (Albert Speer and Partner, 1993; ITE, Georgia IT et al., 1993; Littman, 2002; OECD, 2002). On the other hand, traffic management should encourage operators to provide better quality and higher capacity public transport services.

Goals	Objectives	PT	NMT	IMV: MC	IMV: PC	IM	MM	Truck
To ensure the mobility for all transport demand	To ensure equality in using transport properties	+	+	+	-	++	++	+/-
	To increase the number of modal choices	++	++	+	-	+	+/-	+/-
	To increase the productivity and efficiency of transport supply	+	+/-	+	-	++	+	+/-
	To increase the capacity of transport supply	++	+/-	+	-	+	+	+/-
To ensure safety of all traffic movements	To reduce accident frequency	++	++	-	-	+	+/-	-
	To reduce accident severity	++	++	-	-	+	+/-	-
To protect natural resources and reduce environmental impacts	To reduce air pollutions	+	++	+/-	-	+	+	-
	To reduce traffic noise	+	++	-	-	+	+/-	-
	To save energy consumption in transport	+	++	+/-	-	+	+/-	-
	To save space consumption for transport	++	+	+	-	+	+	-
To improve economy of the city and region	To reduce total transport costs	+	++	+	-	+	+/-	+/-
	To increase economic productivity and efficiency	++	+	+/-	+/-	+	+	+/-
	To improve economic attractiveness	++	+	+/-	+/-	+	+	+/-

Note: PT = Public Transport, NMT = Non-motorised Transport, IMV = Individual Transport Vehicle, MC = Motorcycle, PC = Private Car
IM = Intermodal Transport, MM = Multimodal Transport
++ = highly supportive, **+** : Supportive, **+/-** = depend on specific condition; **-** = opposite

Figure 4-2: Impacts of transport modes on goals and objectives of transport system

- **NMT Rehabilitation and Promotion**

Walking and cycling are the most efficient modes for short distance trips. Moreover, non-motorised transport is the oil-free and emission-free. These characters are hardly found in any other mode, including modern public transport vehicle. Before getting in the motorcycle dependent situation, most of MDCs were in the situation of non-motorised transport dependence. Currently, NMT is still very popular in the MDCs. Therefore, the rehabilitation and promotion of NMT use, especially for short-distance trips, is one of the most feasible orientations in order to achieve the goals of traffic management in MDCs.

- **Individual Motorised Vehicle Use Reduction**

Motorcycle Use Optimisation

In general, the motorcycle is more efficient than other individual motorised vehicles (e.g. private car, pick-up). In contrast, the immaturity of society in response to the motorisation make motorcycle traffic is the most unsafe transport mode in the MDCs. Therefore, an optimal use of motorcycles serving the essential motorised mobility demand can help people in MDCs to avoid the "myth of essential private car transport." In a safer manner and peacefully harmonising with NMT and public transport, motorcycle should continue to be the main individual motorised vehicle in the MDCs. Traffic management measures should try to improve safety and reduce environmental impacts of the motorcycle.

Private Car Use Minimisation

As the most expensive, oil-dependent and polluting passenger transport mode, private cars should be limited for unavoidable car trips only. In urban transport, minimising of car use will reduce the conflicts between cars and other modes in using the road and parking spaces. Therefore, the urban mobility and safety in the MDCs can be effectively improved. The minimisation of car use will help to avoid the risk of become oil-dependent. Moreover, the minimising of car use helps to save the limited resources (land and finance) that are needed for other important development purposes (public health, education, housing and etc.).

- **Intermodal Transport Improvement**

This objective focuses on increasing of possibility to use different transport modes by one trip with convenient and secured interchange between modes. This objective is presented by integration between different urban transport modes (individual motorised vehicles and public transport) and between long-distance and local transport services. The applications of intermodal operational planning and facilities are rising in the last decades and become one of the key traffic management activities.

- **Multimodal Transport Improvement**

This objective focuses on increasing possibility of using transport infrastructure for the transport modes other than IMV. However, the measures would improve also quality and safety of IMV traffic, which may create a side-impact of encouraging some users to drive other than to use other modes. Therefore, planners should consider this side-impact in order to make sure that the increase possibility of using transport infrastructure for other modes must be much higher than the encouragement for driving IMVs.

- **Freight Transport Improvement**

This objective focuses mainly on optimising efficiency of urban truck traffic. As presented in Figure 4-2, the truck traffic creates negative impacts on traffic safety and environment. The impacts of truck traffic on urban mobility and economic depend very much on its operational behaviours. Therefore, traffic management should try to minimise and eliminate the conflicts in using infrastructures and services between trucks and other vehicles. In addition, the measures to reduce environmental impacts of freight transport are definitely required.

4.5.3. Implementation Objectives of Traffic Management

- **Effectiveness**

In the real world, society may not recognise what is the technical design or management concept behind, but it will see, know and response according to the impacts of those designs or concepts on the transport performance. Therefore, the effectiveness of traffic management solutions is measured by the achievement of the strategic goals and objectives.

- **Applicability**

For implementing in a modern civil society, a traffic management solution firstly should be compatible with certain legal bases. Secondly, it needs data, planning tools and proper skills to plan, construct (install) and monitor. Thirdly, it needs sufficient finance to procure materials, technology, knowledge, and human resource. Fourthly, on has to consider the period of establishment and duration of impacts. Finally, it has to be accepted and participated actively by related institutions and individuals in the society.

4.6. Conclusions

This chapter has defined a Strategic Policy Framework (SPF) for traffic management activities in MDCs (see Figure 4-3).

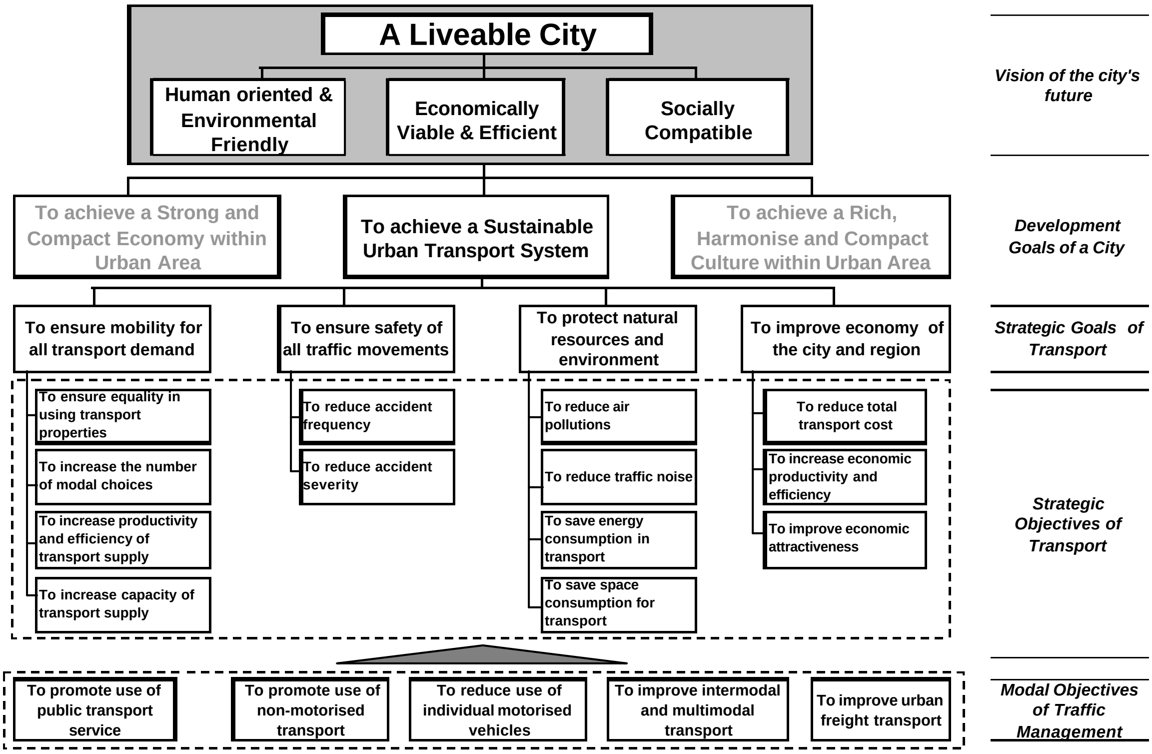


Figure 4-3: Strategic policy framework for traffic management in MDCs

- **The Vision for Future of the City**

The SPF starts with a long-term vision for future development of the urban area, which presents the image of a liveable city, which is human oriented and environmental friendly, economically viable and efficient, and socially compatible. There is no doubt about that the MDCs are also looking on that vision.

- **The Strategic Goals**

The society in the urban area is transported to its vision by a sustainable urban transport system, from which the society expects four major characteristics: mobility, safety, and environmental friendly and economic efficiencies. These characteristics are then defined as four major goals of an urban transport system in any city, including MDCs.

- **The Strategic Objectives**

The goals are sub-divided into more specific and measurable objectives, which are later considered as technical achievement for transport development and management activities in the urban areas. The criteria to measure these objectives are also defined, for example, rate of accidents per one hundred persons is defined to measure the frequency of traffic accident at a specific location or overall urban area.

- **The Development Scenario**

The next step discusses a suitable development scenario for future urban transport system in MDCs. From the literature in the field, one can see very strong advantages of the transit city in comparison with the others. Therefore, this model of urban transport and land use is recommended for MDCs. The development path to a transit city is also defined and, before getting to the end, the modern bus city is recommended to be at the midway.

- **The Modal Objectives**

Although looking for a transit city in the future, the roles of other transport modes in MDCs have to be properly considered. On the other hand, the traffic management actions will be taken and impact directly on vehicles, infrastructure and control system of specific transport modes. Therefore, defining the interactions between transport modes and the strategic goals and objectives of urban transport system again emphasises the needs to give priority for public transport and to have proper impacts on other urban transport modes. The modal objectives are defined as: *public transport prioritisation*, *non-motorised transport promotion*, *individual motorised transport reduction*, *intermodal and multimodal transport improvement*, and *freight transport improvemen*t. These modal objectives open gates for traffic management strategies and measures to contribute on achievement of the strategic vision, goals and objectives.

- **The Implementation Objectives of Traffic Management**

Finally, the expectation from a traffic management solution is defined by two criteria: *effectiveness* and *applicability*. The *effectiveness* is measured by the achievements of strategic goals and objectives of urban transport system, and *applicability* is indicated by the fulfilments of the basic requirements for implementing traffic management measures.

5. Traffic Management Measures for MDCs

In the first part, this chapter presents the structure and process of a multi-criteria assessment model, which was developed to assess traffic management measures in order to recommend a list of effective and applicable measures for the unique conditions of urban development and transport system in the MDCs. Late, sub-chapter 5.2 consists assessment results for each of thirty-four candidate measures.

5.1. Multi-criteria Assessment Model

5.1.1. Pre-selection of Candidate Measures

- **Categorisation of Measures**

According to the definition in sub-chapter 2.1, the candidate measures are firstly selected and categorised by the modal objectives.

Table 5-1: List of candidate traffic management measures

Measure				To avoid traffic			To shift traffic			To control traffic		
No	**Category and title**	**Sub-title**	**Type**	Combining trips	Substitution	Modification	Time	Mode	Destination	Infrastructure	Vehicle	Travellers
PT	**Public Transport Measures**											
1	Public Transport Routing Improvement	*PT Routing*	TE					X	Y	Y		
2	Public Transport Scheduling Improvement	*PT Scheduling*	"					X		Y	Y	
3	Public Transport accessibility Improvement	*PT Accessibility*	"					X		Y		
4	Public Transport Right of Way Prioritisation	*PT Prioritisation*	"				Y	X	Y	Y		
5	Public Transport User Incentives	*PT User Incentives*	ECO				Y	X	Y			
6	Public Transport Information Service	*PT Information*	IN				Y	X	Y			Y
7	Public Transport Management Centre	*Management Centre*	A-O					X		X	Y	
8	Smart Ticketing System	*Ticketing*	"				Y	X	Y			
9	Paratransit Improvement	*Paratransit*	"					X			X	
NMT	**Non-motorised Transport Measures**											
1	Sidewalks and Crossing Facilities	*Pedestrian's Facilities*	TE					X	Y	X		
2	Bicycle Lane and Facilities	*Bicyclist's Facilities*	"					X	Y	X		
3	Non-motorised Transport Zone	*NMT Zone*	"					X	Y	Y		
4	NMT Traffic Information Service	*NMT Information*	IN				Y	X	Y			Y
5	NMT Right of Way Reservation Ordinance	*ROW Reservation*	A-O					X		X		
IMV	**Individual Motorised Vehicle measures**											
1	Right of Way Reduction for Private Car	*ROW Reduction*	TE					X	Y	X		
2	Separation of Motorcycle Traffic	*MC Lane*	"							X		
3	Vehicle Taxes and Duties for IMVs	*Taxes & Duties*	ECO					X			Y	
4	Road Pricing for Private Car	*Road Pricing*	"			Y	X	X	Y			
5	Parking Pricing System	*Parking Pricing*	"			Y	Y	X	X			
6	Parking Information Service	*Parking Information*	"				Y	Y	Y	Y		X
7	Motorcycle Sharing	*MC Sharing*	A-O				Y	X	Y			
8	Vehicle Registration Control	*Registration Control*	"					X			X	Y
MIM	**Multimodal and Intermodal transport measures**											
1	Ringroad System Establishment	*Ringroad*	TE						Y	X		
2	Road Capacity Adjustment	*Capacity Adjustment*	"							X		
3	Signalisation of Intersection Control	*Signalisation*	"							X		
4	Improvement of Non-signalised Intersection Control	*Non-signalised Control*	"							X		
5	Traffic Calming and Speed Reduction	*Traffic Calming*	"				Y	Y	Y	X		
6	Urban Traffic Information Service	*Traffic Information*	IN				Y	Y	Y	Y		X
7	Land Use Change	*Land Use*	A-O	X			Y	Y	X			
8	Flexible Working and School Hour	*Flexible Working Hour*	"				X					Y
9	Road Safety Audit System	*Road Safety Audit*	"							X		
FR	**Freight transport measures**											
1	Urban Truck Traffic Control	*Truck Traffic Control*	TE				X	Y		X		
2	City Logistic Management System Improvement	*City Logistic*	"	X		Y	Y	Y	Y			
3	Freight Taxi Service Improvement	*Freight Taxi*	A-O			X		X				

Note: **X** = primary impact; **Y**: Secondary impact; Blank cell: No considered impact

In Table 5-1, thirty-four candidate measures are initially selected, including nine public transport measures, five non-motorised transport measures, eight measures for individual motorised vehicles, nine measures for multimodal and intermodal transport, and three measures for freight transport and logistics. The characteristics (traffic engineering, economic, information, administrative organisational) and management impacts (traffic avoiding, traffic shifting, and traffic controlling) of these measures are also indicated.

- **Intended Area of Application**

It was clearly defined from the beginning of this study that the candidate measures are selected to apply to *an urban transport system, which serves transport demand within the boundary of a conurbation*. Although some measures can be applied for both urban and regional transport system and some measures may require national level decisions, *this study considers only the applications in and impacts on urban transport system*.

- **Emphasises in Pre-selecting Candidate Measures**

The candidate measures have been firstly selected from the ones that are *already implemented successfully in developing and developed countries*. Many of them are considered as standard transport improvement measures by law and regulations, for example traffic signal control or public transport scheduling. Secondly, the measures, whose impacts are specifically suitable for motorcycle traffic, have been selected favourably.

5.1.2. Structure of the Model

As mentioned in Chapter Two, a multi-criteria assessment model is established for assessing the candidate measures in order to find the most recommendable traffic management measures for MDCs.

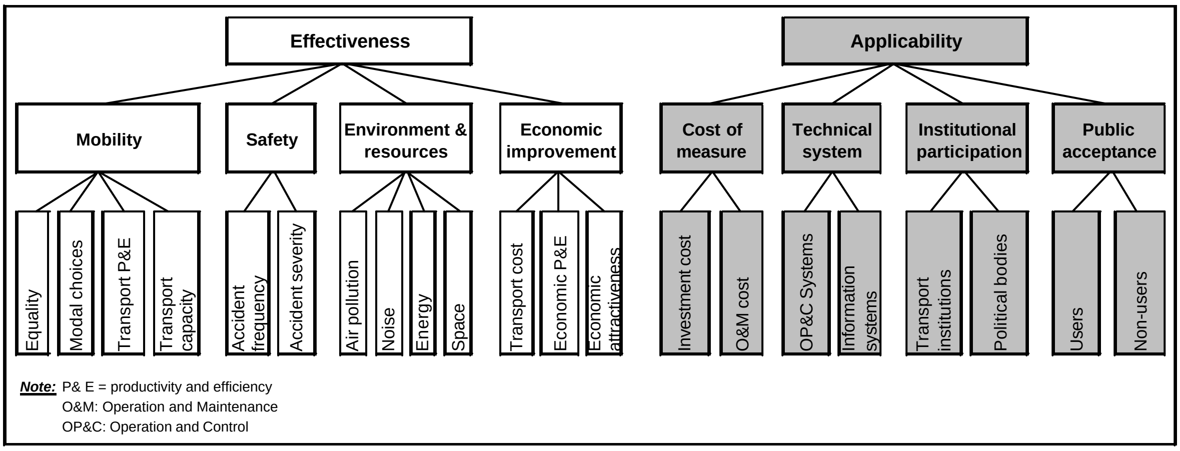


Figure 5-1: Hierarchical structure of assessment criteria

This model is structured from two hierarchical groups of criteria. *Effectiveness* represents the expected impacts and *applicability* represents the main barriers in implantation of traffic management measures in motorcycled dependent cities.

- **Effectiveness Assessment Criteria**

Effectiveness is measured by estimating the impacts of measures toward four strategic *goals* and sub-sequent *objectives* of urban transport system (see Chapter Four).

Mobility

This criterion represents the goal *to ensure urban mobility*, which is achieved by the fulfilment of four objectives, including *to ensure equality in using public transport properties* (represented by sub-criterion equality), *to increase modal choices* (modal choices), t*o increase transport productivity and efficiency* (transport productivity and efficiency), and *to increase capacity of transport supply* (transport capacity).

Safety

This criterion represents the goal *to ensure urban traffic safety*, which is achieved by the fulfilment of two objectives, including *to reduce frequency of traffic accidents* (represented by accident frequency), and *to reduce severity of traffic accidents* (accident severity).

Environment

This criterion represents the goal *to protect urban environment and natural resources*, which is achieved by the fulfilment of four objectives, including *to reduce air pollutions from transport* (subsequent by air pollution), *to reduce noise from transport* (noise), to *save energy consumption in transport* (energy), and *to save urban space using for transport* (urban space).

Economy

This criterion represents the goal *to improve economy of the city and region*, which is achieved by the fulfilment of three objectives, including *to reduce transport cost* (represented by transport cost), *to improve economic productivity and efficiency* (economic productivity and efficiency), t*o improve economic attractiveness of the city and region* (economic attractiveness).

- **Applicability Assessment Criteria**

The *applicability* of measure is indirectly measured by estimating the *difficulty* of the *barriers*, which the MDCs would have to overcome in order to implement the measures. The higher level of *difficulty* in implementation indicates lower level of *applicability* of measure, and vice versa. Four major barriers are considered as criteria for assessing applicability of measure, including *costs of measure*, required *technical systems*, required *institutional participation*, and required *public acceptance*.

Cost of Measure

The first barrier in applying a traffic management is the cost, which defines the *affordability* of the city in implementation of measure. For a specific project, the affordability of measure can be accessed by *cost* and *participation* of bearers. In a general study, it is not possible to define specific participants. Therefore, the *cost of measure* will be the only one criterion for estimating the affordability of measure. The cost of measure contains two components, *investment cost* and *operation & maintenance cost*.

Technical Systems

Beside the internal technical equipments, which are components of the measure, the required technical systems are defined as the additional *operation &control* and/or *information* systems, the provision or improvements of which must be required as basic infrastructures for implementation of the measure.

Institutional Participation

The institutional participation is defined as the required support and participation of the institutions, *which are not the initiator or implementer* of the assessed measure. The required institutions are classified into two groups: *transport related institutions* and *political decision making institutions*. Transport related institutions, subsequent by *transport institutions*, include three sub-groups: (i) transport operators (e.g. bus companies, parking house owners), (ii) transport authorities (e.g. public transport authority, road construction authority), and (iii) traffic enforcers (e.g. traffic police, transport inspection). Political decision making institutions (sub-sequent by political institutions) related to decision of traffic management measures include administrations (e.g. government) and elected institutions (e.g. parliament) of city, region (inter-city) and national level.

Public Acceptance

For implementing a traffic management measure, two main groups of public are concerned. The *users* are clearly defined as the one, who directly use the transport service under impacts of the traffic management measure. The other people, who are affected by implementing the traffic management measure, are defined as *non-users*.

5.1.3. Obtaining the Weights of Assessment Criteria

The weights of effectiveness and applicability criteria groups are obtained by conducting an expert's interview based on the Analytical Hierarchy Process (AHP).

- **Questionnaire Design**

A questionnaire was designed to get expert opinions in each criterion and its sub-criteria.

Q12: To improve economy of the city and region the conditions of a motorcycle dependent city, how should the objectives of TRAFFIC MANAGEMENT be ranked? ***(from the most important (1) to the least important (3) - the same rank can be given for different criteria)***

Objectives	Rank
To reduce transport costs (TCOST)	give here your rank
To improve economic productivity and efficiency (ECO_P&E)	give here your rank
To improve economic attractiveness (ATTR)	give here your rank

Q13: Please formulate the objective-matrix according to the ranks that are given in question 12 and conduct a simple pairewise comparison between the objectives by the following rule:

give "O" if two objectives are equally important

give "+" if the basic objective is slightly more important than the other

Give "++" if the basic objective is significantly more important than the other

Give "+++" if the basic objective is extremely more important than the other

Objective-matrix

			Rank	1	2	3
Basic objectives	Rank/	Title (abrv.)		title	title	title
	Rank 1:	title			give here your rate	give here your rate
	Rank 2:	title				give here your rate
	Rank 3:	title				

Figure 5-2: Example of the questionnaire on expert's opinion interview

Except the three first questions were asked for personal information of the expert, twenty questions were designed to ask expert's opinion on criteria and sub-criteria. At each level of criteria and sub-criteria, experts were firstly asked to give rank for the criteria (sub-criteria). Based on the ranking result, experts were asked to formulate the comparison matrix and conduct a pair wise comparison between the criteria (sub-criteria). The combination of ranking and pair-wise comparison is helpful to improve the consistence and to avoid the first-feeling errors of the judgments.

- **Selection of Experts**

Three groups of transport experts were selected to complete the questionnaire. The first group included four German academic researchers in Darmstadt University of Technology (TUD), who are very familiar with the German traffic management concept. All experts in this group frequently participated in the progress presentations of this study and actively contributed in selecting and grouping assessment criteria. The second group consisted of five Vietnamese transport engineers, who are working as lecturers in University of Transport and Communication in Hanoi (HUTC). They are also working as consultants for transport research and development projects in Vietnam. This group is living and working in real conditions of a motorcycle dependent city. Four of these five experts sent back their answers. The third group consisted of five transport experts, who work for more than ten years as project managers in transport planning consultant companies in Vietnam and other Southeast Asian countries. These persons have good experiences in introducing traffic management and other transport concepts in different developing cities, including MDCs. Only three of the five experts in this group sent back their completed questionnaire.

- **Calculation Weights of the Criteria**

The weights of the criteria (sub-criteria) were obtained by employing the software named EXPERT CHOICE 11.0. The software helps to analyse the comparison matrix by standard nine-point scale (from one to nine) numerically or graphically. Moreover, it also allows the analyst to assign a numerical scale himself in case the nine point scale is not suitable. Therefore, a 0.5 interval scale was assigned to calculating the weights of criteria and sub-criteria based on the graphical analysis of the judgments.

Table 5-2: Scale for pair wise comparison

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the effectiveness
1,5	Moderate importance	Experience and judgment slightly favour one criteria over another
2	Significant Importance	Experience and judgment strongly favour one criteria over another
2,5	Extreme importance	Experience and judgment extremly favour one criteria over another

The comparison matrices of each expert was individually analysed to examine the consistent ratios (for the more than 2x2 matrices) and to calculate the weights. An experience's rate was given according to the working duration in professional. An expert with less than five year work experience was given 1,0. A rate of 1,5 and 2,0 was given respectively to the expert who has worked for between five to ten years and more than ten years. The group's weights were calculated by simple geometric means of the individual weights.

Results of analyses show aggregate opinions of experts that ensuring *traffic safety* is the most important expected impact from traffic management with a weight of 32%, ensuring *urban mobility* ranked second (27%), while the protection of environment and improvement of economy ranked third and fourth with 21% and 20% weight.

	Weight of Criteria (WC)	Criteria		Internal weight of Sub-criteria (WS)	Sub-criteria	Final weight of sub-criteria (WC*WS)	
Effectiveness							
100%	27%	To ensure mobility of transport demand	100%	20%	To ensure equality in using transport properties	5,5%	100%
				26%	To increase number of modal choices	7,1%	
				26%	To increase productivity and efficiency of transport	7,2%	
				27%	To increase capacity of transport supply	7,5%	
	32%	To ensure traffic safety	100%	43%	To reduce accident frequency	13,7%	
				57%	To reduce accident severity	18,3%	
	21%	To protect environment and resources	100%	32%	To reduce air pollution	6,6%	
				26%	To reduce noise pollution	5,5%	
				21%	To save energy	4,4%	
				20%	To save urban space	4,2%	
	20%	To improve economy	100%	30%	To reduce transport costs	6,0%	
				36%	To improve economic productivity and efficiency	7,2%	
				34%	To improve economic attractiveness	6,8%	
Applicability							
100%	25%	Cost of measure	100%	47%	Investment cost	6,6%	100%
				53%	Operation cost	5,5%	
	21%	Technical Systems	100%	57%	Operation and control systems	4,4%	
				43%	Information systems	4,2%	
	26%	Institutional participation	100%	48%	Transport related institutions	6,0%	
				52%	Political institutions	7,2%	
	28%	Public acceptance	100%	62%	Users	6,8%	
				38%	Non-users	0,0%	

Figure 5-3: Weights of the assessment criteria and sub-criteria

In terms of applicability (or difficulty of barriers), although the weights are quite balance between four criteria, achievement of required public acceptance (28%) and institutional participation (27%) are the most difficult jobs in implementation traffic management. The cost of measure and required technical system were ranked lower with 25% and 21% weight. Weights of the sub-criteria of both effectiveness and applicability are presenting in Figure 5-3 (more detail information is presented in Annex D).

5.1.4. Qualitative Scaling of Effectiveness and Applicability

- **Effectiveness**

As mentioned above, effectiveness of measures is assessed by estimating the impacts on the transport system toward the strategic goals and the descendant objectives. Levels of impact are qualitatively scaled (High, Medium, Low and Non) and corresponding points (from 0 to 3 scale) are given for further evaluation.

Mobility

The achievements of four descendant objectives realise the strategic goal *to ensure mobility* in the target urban areas. At this point, it is necessary to emphasise that the absolute new capacity will not be included in the contents of traffic management concept. Therefore, the increase of supply capacity by traffic management is limited to enable of idle existing capacity. The method of qualitative estimation of impacts is presented in Table 5-3.

Table 5-3: Estimation impacts on urban mobility of measures

Objectives	Level of impacts	Description	Point
To ensure equality in using urban transport properties	**High**	This measure will ensure the right to use urban transport properties for all social groups, including the weak travellers (poor people, elders, children, disabilities).	**3**
	Medium	This measure focuses on ensuring the right to use urban transport properties for the major social group **or** the weak traveller group (poor, children, disabilities, elders).	**2**
	Low	This measure focuses on ensuring right to use urban transport properties for a minor but not weak traveller group.	**1**
	Non	The measure creates no impact on this objective.	**0**
To increase modal choice in urban transport	**High**	The measure increases affordability and access to public transport, NMT and other transport modes to all social groups, including week travellers.	**3**
	Medium	The measure increase affordability and access to public transport, NMT and other modes to major social group **or** the weak travellers.	**2**
	Low	The measure increase affordability and access to transport modes for high income people or only minor but not the weak traveller group.	**1**
	Non	The measure creates no impact on this objective.	**0**
To increase productivity and efficiency of transport supply	**High**	The measure will make a significant increase of utilisation of available capacity in term of transport productivity units (total transported passenger or ton) and/or in term of efficiency units (passenger per available road area - hour unit, or ton of good per ton of loading capacity, ton*kilometre per litre of fuel...). Therefore, significant shifting of travel demand from IMVs to public transport or NMT or minimising of empty trucks in freight transport are considered at this level.	**3**
	Medium	The measure will make a moderate increase of utilisation of available capacity in term of transport productivity units or in term of efficiency units. Therefore, some increase in using of public transport, NMT or some reduction of empty trucks are considered at this level.	**2**
	Low	The measure will create only some minor increase of utilisation of available capacity in term of transport productivity unit and/or in term of efficiency. Therefore, the impact to reduce traffic interruptions and delay by controlling and operation without any shifting to public transport or NMT can be considered as low level.	**1**
	Non	The measure creates no impact on this objective.	**0**
To increase capacity of transport supply	**High**	*The measure will provide new facilities or services that increase the absolute supply capacity of the urban transport system (**This level of impact will not belong to traffic management)***	**3**
	Medium	The measure will **enable idle transport facilities or services**, which significantly improve the supply capacity of urban transport system by opening important access to isolated/separated facilities or services, eliminating major bottlenecks.	**2**
	Low	The measure will make some minor increase of supply capacity by eliminating some minor bottlenecks in the system.	**1**
	Non	There is no change in service capacity .	**0**

Safety

On the way to ensure traffic safety, the impacts of measures on reducing accident's *frequency* and *severity* will be estimated. According to Ross, Prassas et al. (2004), there are five categories of impacts in reduction of traffic management frequency and severity. Three of them are in the area of *traffic management* (exposure control, accident prevention, behaviour modification) and the other two are in the areas of *hospital and rescue service* (injury control, and post -injury management). The impact on reducing accident frequency is focused on preventing traffic accidents in general, while the impact on reducing severity of accidents is considered on reduction of the severe accidents (e.g. high speed crashes, public transport accidents).

Table 5-4: Estimation impacts on traffic safety of measures

Objectives	Level of impacts	Description	Point
To reduce accident frequency	High	The measure will help to prevent physically the conflicts between vehicles, vehicles and pedestrians, vehicles and road environment by eliminating the high potential conflicting points on the traffic flow, **or** to reduce the possibility conflicts by significant shifting travel demand from IMVs to public transport or Non-motorised transport (exposure control and accident risk prevention impacts)	3
	Medium	The measure will help to prevent the conflicts by reducing possibility of traffic law violations and eliminating of vehicle errors (strict behaviour control and safe vehicle operation impacts) **or** to reduce the possibility conflicts by a moderate level of shifting travel demand from IMVs to public transport or Non-motorised transport.	2
	Low	The measure will help to reduce the conflicts between vehicles, vehicles and pedestrians, vehicles by soft-separation devices or low-decisive traffic control commands, **or** to reduce the possibility conflicts by some amount of shifting travel demand from IMVs to public transport or Non-motorised transport.	1
	Non	The measure have no impact in reducing accident frequency.	0
To reduce accident severity	High	The measure will help to prevent or significantly reduce the risk of having mass fatality accidents, for example conflicts with public transport vehicles or between heavy vehicles and series of light vehicles.	3
	Medium	The measure will help to prevent or significantly reduce the risk of having severe accidents, for example conflicts between high speed IMVs or between motorised vehicles and NMVs and pedestrian.	2
	Low	The measure will help to reduce slow speed conflicts, which are participated by at least one driving motorised vehicle or between high speed NMVs conflicts.	1
	Non	The measure have no impact in reducing accident severity.	0

Environment and Resources

Achievement of this goal is realised by the obtainments of four descendant objectives, which are (i) to reduce air pollution, (ii) to reduce noise, (iii) to save energy consumption, and (iv) to save urban space. As presented in Chapter Four, the improvement of NMT and public transport showed the highest supportive impacts on protecting environment. Therefore, impacts of measures on these objectives would be highly evaluated if they could promote the use of NMT and public transport. The method of estimation of impacts is presented in Table 5-5.

Table 5-5: Estimation impacts on natural resources and environment of measures

Objectives	Level of impacts	Description	Point
To reduce air pollution	High	The measure helps to prevent polluted vehicles from travelling in the urban transport system or to shift the travel demand from fossil fuelled vehicle to the NMV or very low air polluted transport mode.	3
	Medium	The measure helps to reduce shift travel demand from solo driving fossil fuelled transport mode to the fossil fuelled transit mode or HOV.	2
	Low	The measure helps to redistribute air pollution concentration from peak hour to off-peak period or from high pollution concentration area to the lower concentration areas.	1
	Non	The measure does not help to reduce air pollution.	0
To reduce noise pollution	High	The measure helps to prevent noisy vehicles from travelling in the urban transport system or to shift the travel demand from noisy vehicle to the NMV or very low noise transport mode.	3
	Medium	The measure helps to reduce shift travel demand from solo driving motorised trip to the mass transit mode.	2
	Low	The measure helps to redistribute traffic flow in time and space in order to reduce the synergy effects of noisy vehicle .	1
	Non	The measure does not help to reduce noise.	0
To save energy	High	The measure helps to prevent the use of fossil fuelled vehicles and high energy consumption vehicle from travelling in the urban transport system or to shift the travel demand from motorised vehicle to the NMT modes.	3
	Medium	The measure helps to shift travel demand from solo driving motorised trip to the HOV trip, or the mass transit mode.	2
	Low	The measure helps to reduce energy consumption during traffic operation of vehicle (reduction of delay, reduction of acceleration or deceleration…) .	1
	Non	The measure does not help to save energy	0
To save urban space	High	The measure helps to prevent the use of high space consumption transport mode or to shift travel demand from peak period to off-peak period or to shift the travel demand from solo driving trip to mass transit.	3
	Medium	The measure helps to shift travel demand from solo driving motorised trip to the HOV trip or to shift travel demand from congested road to the other roads.	2
	Low	The measure helps to reduce space consumption by traffic flow operation (reduction of delay, improvement of vehicle traffic flow smoothness) .	1
	Non	The measure does not help to save road space	0

Economy

Three objectives of this goal are (i) to reduce transport costs, (ii) to increase economic productivity and efficiency, and (iii) to improve economic attractiveness. The method of estimation of impacts is presented in Table 5-6.

Table 5-6: Estimation of impacts on economy of measures

Objectives	Level of impacts	Description	Point
To reduce total transport cost	**High**	The absolute reduction of total travel demand can be addressed as the most significant reduction of transport cost. On the other way, the high impact of shifting travel demand from IMV to NMT can also be considered as significant reduction of transport cost.	**3**
	Medium	The moderate and high impact of shifting travel demands from IMV to mass transit services can be considered as the medium reduction of transport cost.	**2**
	Low	The low impact of shifting the travel demand from IMV to mass transit or only the shift from IMV to paratransit services can also be recognise as the reduction of transport cost but at low level.	**1**
	Non	The measure does not help to reduce transport cost.	**0**
To increase economic productivity and efficiency	**High**	The measure will create a significant reduction of distance **and** time of the average trips of passengers and goods.	**3**
	Medium	The measure will create a significant reduction of distance **or** time of the average trips of passengers and goods.	**2**
	Low	The measure will create some minor reduction of distance or time of the average trips of passengers and goods.	**1**
	Non	The measure does not help to improve economic productivity and efficiency	**0**
To improve economic attractiveness of the city an region	**High**	The significant improvement of accessibility by multi modal choices for job and revenue creating activities not only in the targeted area but in overall scale of the city can be considered as high level of improvement of economic competitiveness.	**3**
	Medium	The significant improvement of accessibility for job and revenue creating activities in the targeted area only can be considered as medium level of improvement of economic competitiveness.	**2**
	Low	There are both improvement of accessibility for job and revenue creating activities in the targeted area and reduction the accessibility in the adjoining areas can be considered as low level of improvement of economic competitiveness.	**1**
	Non	The measure does not help to improve economic attractiveness	**0**

- **Applicability**

As mentioned above, applicability of measures is assessed by estimating the difficulty level in getting the basic requirements (called barriers) in implementation of traffic management measures. Levels of difficulty are qualitatively scaled from “Non” to “High” and corresponding points from “0” to “3” scale.

Costs of Measure

The first barrier in applying a traffic management is the cost, which defines the affordability of measure. Measure is affordable when its cost of measure does not exceed the financial ability of the cost bearers (VTPI, 2005). For a specific project, the affordability of measure can be accessed by *cost* and *participation* of bearers.

Table 5-7: Assessment costs of measure

Level of difficulty	Investment cost	Operation cost	Point
High	The investment of new transport infrastructure (road/rail section/lane, main stations, new parking lots, terminal buildings, …) or the additional information technology or power supply infrastructures (telephone network, electricity network)	A new organisation or operation units with new required equipments and employees have to be created in order to operate the measure.	**3**
Medium	The cost is not more than minor adjustment of infrastructure (roadway, parking place, interchanges) and new procurement of operation and control equipments (traffic signals, in-vehicle units, central operation units, computers…)	It requires a significant increase on operation and maintenance costs of operator but there is no need to establish any new organisation or operation for the measures.	**2**
Low	It is only includes the cost for study, planning and documenting, and minor procurement of operation equipments.	It is only some minor increase in the routine operation and maintenance costs of the operators or travellers	**1**
Non	Measure requires no invesment cost	Measure requires no operation cost	**0**

However, in a general study, it is not possible to define the *participation*. Therefore, the *cost of measure* will be the only one criterion for estimating the affordability of measure. The cost of measure contains two components, namely *investment cost* and *operation cost*. There are measures that need very low investment cost but very high operation cost, especially the administrative and organisational measures, and there are measures that require high investment cost, but low operation cost. The method of estimation *level of difficulty* to afford the cost of measure can be defined in Table 5-7.

Technical Systems

Except for the technical equipments that are components of the measure, the required technical systems are defined as the additional *operation/control* and/or *information* systems, whose availability or change is critically required for implementation of the measure. The method for estimating *technical barriers* of traffic management measures is defined in Table 5-8.

Table 5-8: Assessment of technical barriers

Level of difficulty	Operation/Control systems	Information systems	Point
High	Implementation of measure requires changes of overall city traffic operation/control centres for ***all transport modes***	Implementation of measure requires changes of overall city traffic information service (collection, processing and dissemination) for ***all transport modes***	**3**
Medium	Implementation of measure requires changes of overall city traffic operation/control centre for ***a specific mode*** (Public transport, IMV or Truck)	Implementation of measure requires changes of overall city traffic information service (collection, processing and dissemination) for ***a specific mode*** (Public transport, IMV or Truck)	**2**
Low	Implementation of measure requires changes of only local traffic operation/ control equipment	Implementation of measure requires changes of information service at some specific locations.	**1**
Non	No change on operation system is required	No change on information system is required	**0**

Institutional Participation

The institutional participation is defined as the required support and participation of the institutions, *which are not the initiators or implementers* of the assessed measure. There are two major types of institutions, which would be required in order to apply a traffic management measure. Some other types of institutions, for example, the news media, non-government organizations, businesses, and their influences would be presented either by political bodies or as implementers (e.g. business). The method for estimating *technical barriers* of traffic management measures is defined in Table 5-9.

Table 5-9: Assessment of institutional barriers

Level of difficulty	Transport related institutions	Political dicision making institutions	Point
High	Implementation of measure requires participations of ***all three major parties*** of transport related institutions (transport operators, enforcers, and transport authorities)	Implementation of measure requires approvals of ***national*** government and/or general assembly	**3**
Medium	Implementation of measure requires participations of ***two*** over three parties	Implementation of measure requires approvals of ***regional/state*** government and/or regional council	**2**
Low	Implementation of measure requires participations of ***only one*** over three parties	Implementation of measure requires approvals of ***city*** government and/or city council	**1**
Non	No participation of additional transport related institution is required	No other political body is required	**0**

Public Acceptance

For implementing a traffic management measure, two main groups in public are concerned. The *users* are clearly defined as the one who directly use the transport service under the impacts of the traffic management measure. The other people, who are affected by implementing the traffic management measure, are defined as *non-users*. The method for estimating *public acceptance barriers* of measures is defined in Table 5-10

Table 5-10: Assessment of public acceptant barriers

Level of difficulty	Users	Non-users	Point
High	Users would have to pay and participate with change their current travel patterns (mode, time, destination)	People/organisations would have to resettle their residential place or business or manufacturing locations due to implementation of measure	**3**
Medium	Users would have to pay or to participate with changes of current travel patterns	People/organisations would be suffered from negative environmental or economic impacts due to implementation of measure	**2**
Low	Users would have to participate with only some minor change of current travel patterns	People/organisations would be suffered by some minor change of their habit due to implementation of measure.	**1**
Non	Users would have to participate without any change of current travel patterns	People/organisations would not be suffered by any change due to implementation of measure.	**0**

5.1.5. Final Evaluation

Calculation of Effectiveness Score of Measure

Based on the given rates of measure's impacts and the given weights of goals and objectives, one can simply calculate the Effective Score (ES_{ij}) of measure by formula (5-1). Measure would be more effective if the Effectiveness Score is higher, vice versa.

$$ES_{ij} = \sum_{m=1}^{4} WC_m * \left[\sum_{n=1}^{k} WS_{mn} * EP_{mn}^{ij} \right] \quad \text{(Formula 5-1)}$$

Where

ES_{ij}: Effectiveness Score of Measure *j*, under modal category *i*,

$ES_{ij} \geq 2{,}4$: Measure j has High level of Effectiveness

$1{,}5 < ES_{ij} < 2{,}4$: Measure j has Medium level of Effectiveness

$ES_{ij} \leq 1{,}5$: Measure j has Low level of Effectiveness

WC_m: Weight of goal (criterion) *m* (*m* = 1 to 4)

WS_{mn}: Weight of objective (sub-criterion) *n*, under goal *m*

EP^{ij}_{mn}: effective point of measure *j* in category *i*, on objective *n*, under goal *m*

Calculation of Difficulty Score of Measure

Based on the given rates of difficulty of measure and the given weights of criteria and their subordinators, one can simply calculate the Difficulty Score (DS_{ij}) of measure by formula (5-2). Measure would be more applicable if the Applicability Score is higher, vice versa.

$$DS_{ij} = \sum_{x=1}^{4} WC_x * \left[\sum_{y=1}^{x} WS_{xy} * DP^{ij}_{xy} \right] \quad \text{(Formula 5-2)}$$

Where

DS_{ij}: Difficulty Score of Measure *j*, under modal category *i*,

$DS_{ij} \geq 2{,}4$: Measure j has High level of Difficulty in application

$1{,}5 < DS_{ij} < 2{,}4$: Measure j has Medium level of Difficulty in application

$DS_{ij} \leq 1{,}5$: Measure j has Low level of Difficulty in application

WC_x: Weight of criterion *x* (*x* = 1 to 4)

WS_{xy}: Weight of sub-criterion *y*, under criterion *x*

DP^{ij}_{mn}: difficulty point of measure *j* in category *i*, on sub-criterion *y*, under criterion *x*

Terms of Measure Selection

Finally, the measure can be selected to be in the List of Recommended Measures by the following terms:

- The first priority group consists of measures that have a *High level of Effectiveness* and a *Low level of Difficulty* (ES > 2,4 and DS <1,5),
- The second priority group consists of measures that have **either** a *High level of Effectiveness* and *a Medium level of Difficulty* (ES>2,4 and 1,5<DS<2,4), **or** a *Medium level of Effectiveness* and a *Low level of Difficulty* (1,5<ES<2,4 and DS<1,5).
- The third priority group consists of measures, that have a *Medium level of Effectiveness* and *Medium level of Difficulty* (1,5<ES < 2,4 and 1,5<DS <2,4),
- The fourth priority group consists of other measures.

5.2. Assessment of Traffic Management Measures

5.2.1. Overview

After getting through the assessment, fifteen traffic management measures have been selected to be in the first priority group, which includes five public transport measures, three NMT measures, two individual vehicle measures, four multimodal and intermodal transport measures and one freight transport measures. The other nineteen measures are assigned in the second (14 measures), third (2 measures) and fourth (3 measures) priority group. Detailed results of assessment are presented in Annex E.

Table 5-11: Assessment of traffic management measures for MDCs

Measure				Effectiveness				Applicability				Priority group
No	**Category and title**	**Sub-title**	**Type**	Mobility	Safety	Environment & Resource	Economy	Cost of measure	Technical systems	Institution	Public acceptance	
PT	**Public Transport Measures**											
1	**Public Transport Routing Improvement**	*PT Routing*	TE	●	●	◉	◉	⊙	⊙	⊙	⊙	**1**
2	**Public Transport Scheduling Improvement**	*PT Scheduling*	"	●	●	◉	●	◉	◉	⊙	⊙	**1**
3	Public Transport accessibility Improvement	*PT Accessibility*	"	●	◉	◉	◉	⊙	⊙	⊙	○	**2**
4	Public Transport Right of Way Prioritisation	*PT Prioritisation*	"	●	●	◉	●	◉	⊙	◉	◉	**2**
5	**Public Transport User Incentives**	*PT User Incentives*	ECO	●	●	◉	◉	◉	○	⊙	○	**1**
6	**Public Transport Information Service**	*PT Information*	IN	●	●	◉	●	⊙	○	⊙	○	**1**
7	**Public Transport Management Centre**	*Management Centre*	A-O	●	●	◉	●	●	⊙	⊙	○	**1**
8	Smart Ticketing System	*Ticketing*	"	●	◉	◉	●	⊙	⊙	⊙	○	**2**
9	Paratransit Improvement	*Paratransit*	"	◉	◉	⊙	◉	◉	⊙	◉	○	**2**
NMT	**Non-motorised Transport Measures**											
1	**Sidewalks and Crossing Facilities**	*Pedestrian's Facilities*	TE	●	◉	●	●	⊙	◉	⊙	◉	**1**
2	Bicycle Lane and Facilities	*Bicyclist's Facilities*	"	◉	◉	◉	●	◉	⊙	⊙	●	**3**
3	**Non-motorised Transport Zone**	*NMT Zone*	"	◉	●	●	◉	◉	⊙	⊙	◉	**1**
4	**NMT Traffic Information Service**	*NMT Information*	IN	●	◉	●	◉	⊙	⊙	⊙	○	**1**
5	NMT Right of Way Reservation Ordinance	*ROW Reservation*	A-O	◉	●	●	⊙	◉	⊙	⊙	○	**2**
IMV	**Individual Motorised Vehicle Measures**											
1	Right of Way Reduction for Private Car	*ROW Reduction*	TE	◉	●	◉	●	⊙	⊙	⊙	⊙	**2**
2	Separation of Motorcycle Traffic	*MC Lane*	"	◉	●	⊙	◉	⊙	◉	⊙	◉	**3**
3	**Vehicle Taxes and Duties for IMVs**	*Taxes & Duties*	ECO	◉	●	●	●	⊙	○	◉	●	**1**
4	Road Pricing for Private Car	*Road Pricing*	"	◉	◉	◉	●	⊙	○	●	⊙	**2**
5	Parking Pricing System	*Parking Pricing*	"	◉	◉	◉	◉	⊙	⊙	⊙	◉	**2**
6	Parking Information Service	*Parking Information*	"	◉	⊙	⊙	⊙	⊙	⊙	⊙	○	**4**
7	Motorcycle Sharing	*MC Sharing*	A-O	⊙	◉	⊙	⊙	⊙	⊙	⊙	⊙	**4**
8	**Vehicle Registration Control**	*Registration Control*	"	◉	●	●	●	◉	○	●	◉	**1**
MIM	**Multimodal and Intermodal Transport Measures**											
1	Ringroad System Establishment	*Ringroad*	TE	●	●	⊙	◉	⊙	⊙	⊙	⊙	**2**
2	Road Capacity Adjustment	*Capacity Adjustment*	"	●	◉	⊙	●	⊙	⊙	⊙	⊙	**2**
3	**Signalisation of Intersection Control**	*Signalisation*	"	●	●	◉	●	⊙	⊙	⊙	○	**1**
4	Improvement of Non-signalised Intersection Control	*Non-signalised Control*	"	◉	●	◉	◉	◉	⊙	⊙	⊙	**2**
5	**Traffic Calming and Speed Reduction**	*Traffic Calming*	"	●	●	●	●	⊙	◉	⊙	⊙	**1**
6	**Urban Traffic Information Service**	*Traffic Information*	IN	●	●	◉	●	◉	⊙	⊙	○	**1**
7	**Land Use Change**	*Land Use*	A-O	●	●	●	●	◉	⊙	⊙	⊙	**1**
8	Flexible Working and School Hour	*Flexible Working Hour*	"	◉	⊙	⊙	⊙	⊙	⊙	⊙	◉	**4**
9	Road Safety Audit System	*Road Safety Audit*	"	⊙	●	⊙	⊙	⊙	○	⊙	○	**2**
FR	**Freight Transport Measures**											
1	Urban Truck Traffic Control	*Truck Traffic Control*	TE	◉	◉	◉	⊙	⊙	⊙	⊙	◉	**2**
2	**City Logistic Management System Improvement**	*City Logistic*	"	●	●	⊙	●	⊙	○	⊙	⊙	**1**
3	Freight Taxi Service Improvement	*Freight Taxi*	A-O	◉	⊙	⊙	◉	⊙	⊙	⊙	○	**2**

Note: ●= High; ◉= Medium; ⊙=Low; ○= Non

5.2.2. Public Transport Measures

The assessments results indicate that the most recommended traffic management improvements on public transport service in MDCs are *PT routing*, *PT scheduling*, *PT users incentives*, *PT information*, and *Management centre*. Implementation of these five measures will help to improve both *availability and affordability of public transport service*. Looking at public transport measures in the second priority group, one can recognise the next recommended improvement of public transport, the *quality service*, which requires better physical accessibility, high priority right of way, and easier service purchasing. The second rank of *paratransit* is properly evaluated by its relative lower effectiveness in comparison with other public transport measures.

5.2.3. Non-motorised Transport Measures

Three non-motorised transport measures are selected in the first priority group. The first measure is to ensure sufficient and safe *sidewalks and pedestrians crossing facilities*. The emphasis on establishing *NMT zon*e indicates unique condition of MDCs, where most of the urban population live in the two-wheeler accessed only blocks. This condition presents a good availability of the alley network within the two-wheeler accessed only blocks. Therefore, a good *NMT information* service should be provided to help NMT users utilise the available alleys for their travel demand. In addition, an ordinance for reservation of Right-of-Way for NMT is also important, but it can be applied for the new urban roads only. One may ask for provision of bicycle lanes and parking facilities, but lack of road space, high cost of land, and difficulty in acquiring area do not allow this measure to be simply applied in MDCs. On the other hand, in MDCs the bicyclists have possibilities to share road space with motorcycles on the relative slow urban traffic stream on the roads and alleys, and to use the same parking facilities of motorcycles.

5.2.4. Individual Motorised Vehicle Measures

Only two individual motorised vehicle measures are recommended to present in the first priority group. Unfortunately, these measures (*Taxes and Duties* and *Registration control*) are frequently encounter difficulties in getting participation of institutions and acceptance of IMV drivers and manufacturers. However, they are highly effective and easier to apply in MDCs in terms of cost and technical requirements. The famous *road pricing* and *parking pricing* are located in the second priority group. The motorcycle specified measure, *separation of motorcycle traffic*, is even assigned in the third priority group. Another motorcycle specified measure, *MC sharing*, and *parking information* ranks fourth due to the low level of effectiveness, while their level of difficulty in implementation is also low.

5.2.5. Multimodal and Intermodal Transport Measures

The presentation of four multimodal and intermodal transport measures in the list indicates needs of improving the general conditions of urban transport system in MDCs. The improvement of *Traffic Signal Control* and provision of static *Urban Traffic Information* service are highly effective and applicable measure. The application of *Traffic Calming and Speed Reduction* is suitable with the high-density city centres and with the two-wheeler accessed only blocks in MDCs. *Land Use Change* is highly recommended for application in MDCs, for example, providing a series of shopping malls and health care services in the two-wheeler accessed only areas or providing student accommodation in surrounding areas of the universities. *Ringroad System* and *Road Capacity Adjustment* ranked second by a low level of effectiveness in protecting environment. However, these are very important support tools for other first rank measures. *Road Safety Audit* is also ranked second due to its low level of impact in the no traffic safety related criteria. The *Flexible Working and Schooling Hours* is the most unpopular measure among the multimodal transport measures.

5.2.6. Freight Transport Measures

City Logistic management system is selected in the first priority group due to its high effectiveness and applicability (low difficulty level). The other two measures are ranked second due to their lower effectiveness, though they are largely applied in many MDCs.

5.3. Conclusions

This chapter firstly established a multi-criteria assessment model to assess and select the most suitable traffic management measures to recommend for the MDCs. Secondly, it conducted the assessment process for thirty-four candidates and finally classified these measures into four priority groups.

- **Assessment Model**

A multi-criteria assessment model is applied to assessment of the candidate measures and to recommend the most suitable measures for MDCs. In this model, two major criteria are *effectiveness* and *applicability* of candidate measures are assessed based on strategic goals of traffic management and basic barriers for implementing traffic management activities.

Two AHP structures are established representing two sub-models, *effectiveness* and *applicability*. A questionnaire survey among three groups of transport experts was conducted to obtain the weight of criteria and sub-criteria of the two sub-models. AHP-based software, EXPERT CHOICE (version 11.0), was employed to analyse the consistent ratio of the answers and to obtain the weights.

In terms of effectiveness, the traffic safety was rated as the most expected improvement of urban transport in the MDCs (32% weight). The followings are mobility (27%), environment and resources (21%), and economy (20%). In term of applicability, public acceptance has been rated the most difficult barrier (28%). The following are institutional participation (26%), cost of measure (25%) and technical systems (21%).

It is necessary to emphasise here that designated users of this model are not the conventional traffic managers or a decision makers who have to make a “Yes” or “No” decision for a specific city. The model’s users stay in a neutral position to assess and recommend traffic management measures based on the distinguished applicability barriers of MDCs from the other more developed cities.

The next step is to evaluate the measures based on results of the estimations. The priority in recommendation of traffic management measures for MDCs are selected according to the following terms:

- The first priority group consists of measures that have a *High level of Effectiveness* and a *Low level of Difficulty* (ES > 2,4 and DS <1,5),
- The second priority group consists of measures that have **either** a *High level of Effectiveness* and *a Medium level of Difficulty* (ES>2,4 and 1,5<DS<2,4), **or** a *Medium level of Effectiveness* and a *Low level of Difficulty* (1,5<ES<2,4 and DS<1,5).
- The third priority group consists of measures, that have a *Medium level of Effectiveness* and *Medium level of Difficulty* (1,5<ES < 2,4 and 1,5<DS <2,4),
- The fourth priority group consists of other measures.

It is necessary to emphasize that the recommended measures are qualitatively assessed and selected according to the existing urban and transport conditions of the low income MDCs. Therefore, the results of this study may be different from others, which were conducted based on other urban development and transport backgrounds.

- **Assessment of Traffic Management Measures**

Finally, fifteen traffic management measures have been selected to be in the first priority group, which includes five public transport measures, three NMT measures, two individual vehicle measures, four multimodal and intermodal transport measures and one freight transport measures. The other nineteen measures are assigned in the second (14 measures), third (2 measures) and fourth (3 measures) priority group. Detailed results of the assessment are presented in Annex E.

In general, the first priority group was built from a good mix of measures, which represent the traffic management activities in all forms and modes of urban transport system. Although the levels of impacts may be varied according to specific conditions of cities, each measure of the list is highly recommended to apply in every MDC and in other developed and developing cities. With an objectives-led approach in Traffic Management Planning, the measures in the first priority group are recommended to be the Basic Measures of traffic management strategies.

The final emphasis here is that, the implementation of any traffic management measure needs sufficient protection of traffic laws, effective and promptly enforcement service, and good awareness of all stakeholders. Although improvements of traffic laws, enforcement service and traffic education are not studied in this chapter as traffic management measures, they are always presented as the fundamental requirements for traffic management in particular and urban transport development in all MDCs.

6. Traffic Management Strategies in MDCs

This chapter focuses on formulating applicable traffic management strategies based on the first priority traffic management measures, which are recommended as the outcomes of Chapter Five. In section 6.2, a two-steps formulation model is presented as the recommended process to systematically integrate different traffic management measures into strategic traffic management packages, which presented as different alternatives in Traffic Management Planning. Following this model, the *Basic Traffic Management Measures*, *Supportive Traffic Management Measures* and specific *Conflict-Solving Measures* (non-traffic management) are proposed and assessed in order to formulate the strategy package.

The sections from 6.3 to 6.6 present the formulation process of four typical traffic management strategies for MDCs. It is necessary to emphasise that the strategies are formulated for applying at the general level (for all transport modes) and for overall conurbation of the city. However, the modified versions of the strategies can be applied for the specific and lower scale urban transport situations in MDCs, such as central business districts (or city centre), two-wheeler accessed only blocks, and urban arterials.

6.1. Strategy Formulation Model

6.1.1. Model Structure

After getting the priority list of measures, a two-step model is established to formulate possible traffic management strategies for MDCs.

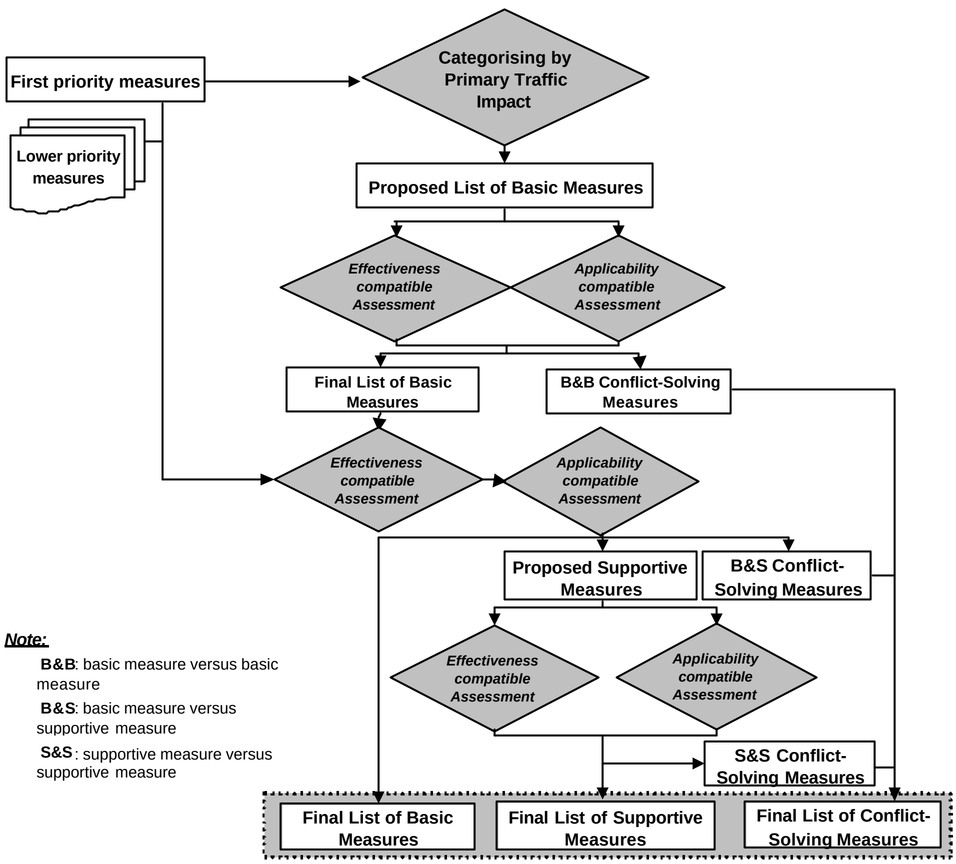


Figure 6-1: Traffic management strategy formulation model

The first step is defining the basic traffic management measures, subsequently ***Basic Measures,*** whose implementation is the major efforts for achieving the urban transport goals and objectives. Difficulties and conflicts in implementation of the Basic Measures would be solved by additional measures (see Supportive Measure and Conflict-Solving Measure).

The second step is to define the supportive traffic management measures, subsequently ***Supportive Measures***, which aim to improve applicability or to reduce level of difficulty in the implementation of the Basic Measures.

The remained difficulties and conflicts in implementation of the Basic Measures would be solved by specific non-traffic management measures, called ***conflict-solving measures.*** The conflicts in integration of the Supportive Measures in the package also require other Conflict-Solving Measures.

Finally, the content of traffic management strategy is formulated including the ***Basic Measures***, the ***Supportive Measures*** and the ***Conflict-Solving Measures*** (see Figure 6-1).

6.1.2. Defining Basic Traffic Management Measures

- **Proposed Basic Measures**

The Basic Measures are proposed based on the primary traffic impact (to avoid, to shift and to control traffic) of the first priority traffic management measures. As presented in Table 6-1, fifteen measures are recommended into the first priority group of measures.

Table 6-1: The first priority traffic management measures

Measure					Traffic impact: To avoid traffic			Traffic impact: To shift traffic			Traffic impact: To control traffic		
No.	Code	Title	Sub-title	Type	Combining trips	Substitution	Modification	Time	Mode	Destination	Infrastructure	Vehicle	Travellers
1	PT1	Public Transport Routing improvement	PT routing	TE					X	Y	Y		
2	PT2	Public Transport Scheduling improvement	PT scheduling	"					X		Y	Y	
3	PT5	Public Transport users incentives	PT User incentives	ECO				Y	X	Y			
4	PT6	Public Transport Information Service	PT Information	IN				Y	X	Y			Y
5	PT7	Public transport management centre	Management centre	A-O				Y	X		Y	Y	
6	NMT1	Sidewalks and crossing facilities	Pedestrian's facilites	TE					X	Y	X		
7	NMT3	Non-motorised transport zone	NMT zone	"					X	Y	Y		
8	NMT4	NMT traffic information service	NMT information	IN				Y	X	Y			Y
9	IMV3	Vehicle Taxes and Duties for IMVs	IMV's Taxes & Duties	ECO					X			Y	
10	IMV8	Vehicle registration control	Registration control	A-O					X			X	Y
11	MIM3	Signalisation of intersection control improvement	Signalisation	"							X		
12	MIM5	Traffic calming and speed reduction	Traffic calming	"				Y	Y	Y	X		
13	MIM6	Urban traffic information service	Traffic information	IN				Y	Y	Y	Y		X
14	MIM7	Land use changes	Land use	A-O	X			Y	Y	X			
15	FR2	City logistic management system improvement	City logistic	"	X		Y	Y	Y	Y			

Note: **X** = primary impact; **Y**: Secondary impact; Blank cell: No considered impact
PT: Public Transport, NMT: Non-motorised transport, IMV: Individual motorised vehicle,
MIM: Multi- and intermodal transport, FR: Freight transport
TE: Traffic Engineering, ECO: Economic, IN: Information, A-O: Administrative and Organisational

In terms of primary traffic impact, two measures can be defined as *traffic avoiding measures*, specifically by combining trips (*Land Use Change*, and *City Logistic*), other elevens are traffic shifting measures, and five measures have traffic controlling impact, three measures have more than a single primary impact.

- **Compatibility Assessment of Basic Measures**

The compatibility between measures is assessed by two groups of criteria, *effectiveness* and *applicability*. *Effectiveness compatible measures* are helping each other to increase level of achievement of the strategic goals. A*pplicability compatible measures* support each other to reduce the level of difficulty of barriers in application.

Effectiveness Compatible Assessment

Based on the strategic policy framework, effective compatibility between two measures is assessed in four strategic goals of urban transport system: *(i) to ensure urban mobility, (ii) to ensure traffic safety, (iii) to protect urban environment and resources*, and (iv) *to improve urban economy*. In each goal, relation between measures is qualitatively assessed to prove that the two measures are *complementary*, *neutral* or *mutually conflict*. In each criterion, relations of two measures are assessed as the followings:

- *Complementary*, if the implementation of two measures together yields a synergy benefit, as presented by the following formula:

  Effectiveness (B1+B2) ³ max (Effectiveness (B1), Effectiveness (B2))

- *Neutral*, if the implementation of two measures together yields a similar level of effectiveness as implementation of each measure individually:

  Effectiveness (B1+B2) = Effectiveness (B1) = Effectiveness (B2)

- *Mutually conflict*, if the implementation of two measures together yield a lower level of effectiveness than implementation of two measures individually:

  Effectiveness (B1+B2) < max (Effectiveness (B1), Effectiveness (B2))

In terms of effectiveness, the basic traffic management measure would be recommended for formulating the strategy's kern by the following conditions:

- Measure will be recommended if *it does not mutually conflict* with any other Basic Measure.
- Measure would be recommended if its conflicts with other Basic Measures could be solved by additional measures.
- Measure will not be recommended if its conflicts with any other Basic Measure cannot be solved by additional measures.

Applicability Compatible Assessment

Applicable compatibility between two measures is assessed in four criteria *(i) cost of measure, (ii) required technical systems, (iii) required institutional participation*, and (iv) *public acceptance*. In each criterion, relation between measures is qualitatively assessed to prove that the two measures are *complementary*, *neutral* or *mutually conflic*t.

In each criterion, relation of two measures is assessed as the followings:

- *Complementary*, if the implementation of two measures together faces a lower level of difficulty than implementation of two measures individually:

  Level of Difficulty (B1+B2) < max (Level of (Difficulty (B1), Level of Difficulty (B2))

- *Neutral*, if the implementation of two measures together faces a similar level of difficulty as implementation of each measure individually, as presented by the following formula:

  Level of Difficulty (B1+B2) = Level of Difficulty (B1) = Level of Difficulty (B2)

- *Mutually conflict*, if the implementation of two measures together faces a higher level of difficulty than implementation of two measures individually, as presented by the following formula:

  Level of Difficulty (B1+B2) ^{3} *ma*x (Level of (Difficulty (B2), Level of Difficulty (B2)).

Measures will be recommended to form the kern of strategy in the following conditions:

- Measure will be recommended if *it does not mutually conflict* with any other Basic Measure.
- Measure would be recommended if its conflicts with other Basic Measures could be solved by additional measures.
- Measure will not be recommended if its conflicts with any other Basic Measure cannot be solved by additional measures.

6.1.3. Defining Supportive Traffic Management Measures

- **Proposed Supportive Measures**

As first, Supportive Measures are required to implement in order to improve the *applicability* of Basic Measures in the traffic management strategy. Therefore, in combining the Basic Measures, remained *high or medium level of difficulty* barriers would require specific measures, which can help to overcome these difficulties.

Secondly, any new higher level of difficulty, which was brought into the strategy package by the inclusion of any Supportive Measure, would be considered as a conflict requiring specific Conflict-Solving Measures.

The candidate Supportive Measures are firstly selected from the first priority measures and then from the lower ones. In the framework of this chapter, Supportive Measures would be selected only from the first priority list in order to demonstrate a possibility of packaging Supportive Measures into a strategy.

- **Compatibility Assessment between Supportive and Basic Measures**

Effectiveness Compatible Assessment

Although improvements of effectiveness are not concerned, the candidate measure will be simply excluded if it tends to create negative impacts on effectiveness of the Basic Measures, as in the following formula:

Effectiveness (S+B) < Effectiveness (B)

Applicability Compatible Assessment

The compatibility between proposed Supportive Measure and the Basic Measures in the applicability aspects is assessed as follows:

- *Complementary*, if the implementation of the Supportive Measure (S) and the Basic Measure (B) together faces a lower level of difficulty than implementation of two measures individually:

  Level of Difficulty (S+B) < max (Level of (Difficulty (S), Level of Difficulty (B))

- *Neutral*, if the implementation of the Supportive Measure (S) and the Basic Measure (B) together faces a similar level of difficulty as implementation of each measure individually:

  Level of Difficulty (S+B) = Level of Difficulty (S) = Level of Difficulty (B)

- *Conflict*, if the implementation of the Supportive Measure (S) and the Basic Measure (B) together faces a higher level of difficulty than implementation of two measures individually, as the following formula:

  Level of Difficulty (S+B) ^{3} *max (Level of (Difficulty (S), Level of Difficulty (B)).*

Measures will be recommended for further assessment based on the following conditions:

- Measure will be proposed if *it does not mutually conflict* with any Basic Measure.
- Measure would be recommended if its conflicts with the Basic Measures could be solved by additional measures.
- Measure will not be recommended if its conflicts with any Basic Measure cannot be solved by additional measures.

- **Compatibility Assessment between Supportive Measures**

In this step, proposed Supportive Measures will be assessed once in order to finalise the list of Supportive Measures in the strategy. Although the effectiveness of Supportive Measures is not considered as part of the main impact of the strategy, the implementation of them ensures that Basic Measures are applicable. Therefore, mutual relations between Supportive Measures will be assessed in both group of criteria *effectiveness* and *applicability* as similar to the assessment of compatibility between Basic Measures.

In each criterion, finale list of Supportive Measures is selected by the following conditions:

- Measure will be selected if *it does not mutually conflict* with any other Supportive Measure.
- Measure can be selected if its conflicts with other Supportive Measures could be solved by additional measures.
- Measure will not be selected if its conflicts with any other Supportive Measure could not be solved by additional measures.

6.1.4. Conflict-Solving Measures

In assessing the compatibility between measures, potential conflicts between them would be discovered. In dealing with the conflicts, the supportive traffic management measures would firstly required. However, many conflicts cannot be solved by traffic management measures, thus requiring specific non-traffic management measures. Following the strategy formulation process, three groups of Conflict-Solving Measures will be proposed according to the conflicts between Basic Measures (B&B), between Basic and Supportive Measures (B&S), and between Supportive Measures (S&S).

It is important to emphasise that the benefit of integration between two traffic management measures must be bigger than the total cost of required Conflict-Solving Measures. Moreover, the Conflict-Solving Measures will not be considered as traffic management measures. They will not create any considerable traffic avoiding, shifting or controlling impact. Conflict-Solving Measures will be proposed specifically according to the situation of conflicts, which cannot be solved by supportive traffic management measures. Therefore, the Conflict-Solving Measures can only be defined according to specific urban development and transport conditions of a specific case (road A, or city B), and they will not mentioned in detail in the proposed traffic management strategies for MDCs in this chapter.

6.1.5. Packaging Content of the Strategy

- **Final List of Basic Measures**

The final list includes the mutually supportive Basic Measures in terms of effectiveness and applicability. No mutual conflict between the Basic Measures remains unsolved.

- **Final List of Supportive Measures**

The list includes measures, whose implementation helps to improve the applicability of the Basic Measures. Moreover, no mutual conflict between selected Supportive Measures themselves or between them and the Basic Measures remains unsolved.

- **Final List of Conflict-Solving Measures**

The list includes all required measures, whose implementation helps to solve the conflicts of integration of the traffic management measures (B&B, B&S, S&S) efficiently.

6.2. Traffic Avoiding Strategy

6.2.1. Basic Measures

- **Proposed measures**

As defined in Chapter Two, this strategy merely influences urban transport system by the traffic avoiding impact, specifically by combining personal and freight trips. Therefore, it is formulated from the Basic Measures, which have traffic avoiding as the primary impact. In the firs priority group, two possible Basic Measures of the Traffic Avoiding Strategy are:

  - Land Use Change, and
  - City Logistic Management System

- **Effectiveness compatible assessment**

To ensure urban mobility

The application of *Land Use Change* in MDCs aims to combine different land uses in a certain area, where different human purposes can be accessed within a short travel radius (by walking or by internal transporters). This also requires good logistic systems, provided by *City Logistic*, in order to supply goods and services for such multi-activities areas. On the other hand, the combination of activities creates high demand logistic origins and destinations and reduces significantly vehicle travel demand for collecting and distributing goods and services. Implementation both measures together help to increase at once opportunities for people in using transport properties for serving both passenger and goods transport demand. It also creates good options for individuals and/or organisations to access for different purposes by walking and/or to send and receive goods by city logistic system.

To ensure urban traffic safety

The main impact on ensuring urban traffic safety of *Land Use Change* is reducing frequency of accidents in general and the severe accidents in particular by absolute reduction of inter-areas transport demand in the city. The impact of *City Logistic* reduces frequency and severity of accidents via reducing heavy truck in overall network by establishing optimal truck tours (routing an scheduling) for colleting and distributing goods. The combination of different land uses within certain areas concentrates goods and service transport demand and creates a good condition to optimise the routing and scheduling logistic service (by *City Logistic*). Therefore, these two measures are mutually supportive in achieving the safety goal.

To protect urban environment and resources

The main impact on protecting urban environment and resources of *Land Use Change* is reducing air pollution, noise, energy, and space consumption by absolute reduction of inter-areas transport demand in the city. The impact of *City Logistic* is reducing environmental impact via reducing travel demand of heavy truck in overall network by establishing optimal truck tours (routing an scheduling) for colleting and distributing goods. The combination of different land uses within certain areas concentrates goods and service transport demand and creates a very good condition to optimise the routing and scheduling logistic service. However, the concentration of truck traffic in the networks around activities centres will definitely increase environmental pollutions and space consumption in these centres. Therefore, additional measures to deal with the truck traffic concentration problem must be implemented in the targeted area of *Land Use Change* in the case *City Logistic* would also be implemented together.

To improve economy of city and region

The concentration of different land uses in certain areas by *Land Use Change* and provision of good logistic services (by *City Logistic*) will definitely enhance economic development of the targeted area, the city and overall region. The high land use density enhances efficiency and productivity of production, transport service and exchange of information of the targeted area. Good logistic services can increase productivity and efficiency of inter-areas economic relations.

- **Applicability compatible assessment**

Cost

In principle, the combination of measures will sum up a total amount, which must be bigger than the cost of any single measure, thus creating cost conflict. A very important cost advantage of this strategy is that the investment costs of for modification of buildings (by *Land Use Change*) and establishing distribution centres and operation cost of logistic services (by *City Logistic*) will be paid by the private investors (new land users). The public budget has to pay for the cost of improvements of parking facilities or public transport stations and operation costs of the new public land uses (schools, kindergartens) (in *Land Use Change*). The amount of tax exemption for some encouraged amount is also accounted for public budget. There is no significant evidence of inter-financing between *Land Use Change* and *City Logistic*. Therefore, a financial measure is required in dealing with this cost conflict, but it is not at a high level of difficulty. Moreover, the combination of two measures will help to reduce some study cost and some saving in acquisition of land or required space for logistic stations at the changed urban areas (by *Land Use Change*).

Required technical systems

As similar to the interrelation in cost, there is no either mutual support or conflict between *Land Use Change* and *City Logistic* in term of technical systems. Moreover, the combination faces only a low level of difficulty in required technical systems. Therefore, no supportive or Conflict-Solving Measure is required in this aspect.

Institutional participation

Although there is no evidence of conflict or support between two measures in achieving participation from transport related institutions, a package of *Land Use Change* and *City Logistic* will be easier to get required approvals from political decision makers than only a single measure. *City Logistic* ensures that the supply of logistic service is well available for the additional good and service transport demand, which would be created by MIM7. Thus, to protect the politicians from the protest of citizens and businesses due to a lack of logistic services in changing of land uses.

Public acceptance

The combination of *Land Use Change* and *City Logistic* is strongly supported by transport users (travellers and good transport customers) and the logistic service providers. On one hand, *Land Use Change* creates a good opportunity for business to invest on logistic industry. On the other hand, *City Logistic* ensures people and businesses that their generated or changed good transport demands will be well served. Although the combination is expected to serve also the impacted land users, who have to relocate their home, properties or business for implementing *Land Use Change*, the high level of difficulty in getting acceptance of this group is still remaining, especially in the city centres. Therefore, Supportive Measure is required to overcome this difficulty.

6.2.2. Supportive Measure

- **Proposed Supportive Measure**

As mentioned above, the most difficult barrier in implementation of package *Land Use Change* and *City Logistic* is getting acceptance of the impacted land users and the considerable amount of the total cost. The approach here is to improve the awareness of land users and to give them acceptable compensation in term of financial and social benefit. The means on this approach are mainly on the field of human and business resettlement other than in traffic and transport. However, a sufficient financial compensation can help to reduce the level of difficulty in this barrier. Looking through the list of first priority measures, *Vehicle Taxes and Duties for IMVs (Taxes & Duties)* is the only measure that generates financial resource. Therefore, it is proposed to be the Supportive Measure in this strategy.

- **Compatibility between Supportive and Basic Measures**

With regard to effectiveness, the most serious conflict can be expected by the inclusion of *Taxes & Duties* is the impact distortion. The implementation of *Taxes & Duties* can shift a significant portion of IMV drivers to travel by public transport and NMT although the implementation of *Land Use Change* and *City Logistic* definitely reduces the demand of travelling by IMVs, but only in the land use changed areas. Thus, the impact of this strategy would no more mere *avoiding*, but rather be a combination between avoiding and *shifting*. Therefore, IMV3 will be rejected.

6.2.3. The Strategy Package

The Traffic Avoiding Strategy in MDCs consists of four traffic management measures. By their primary traffic impact, *Land Use Change* and *City Logistic* are defined as the Basic Measures of the strategy. The *Taxes & Duties* is proposed as the Supportive Measure. However, the distortion of strategy's impact is the main reason to exclude this measure from the strategy package. In implementation of this strategy, Supportive Measures in the field of human and business resettlement are required in order to ensure the dis-benefits by relocating of residential and business places in implementation of *Land Use Change* are equally compensated.

6.3. Traffic Shifting Strategy

6.3.1. Basic Measures

- **Proposed Measures**

As presented in the list of first priority measures, shifting travel demand in transport mode is the primary impact of ten over eleven traffic-shifting measures. The only destination shifting measure is *Land Use Change* and was already assigned in the Traffic Avoiding Strategy. By the strategy formulation model, a destination Traffic Shifting Strategy with the *Land Use Change* as the Basic Measure can be formulated in the same manner. In this chapter, Traffic Shifting Strategy is focused on the modal shifting impact. Therefore, a list of ten measures is proposed to formulate the kern of this strategy as the followings:

- Public Transport Routing Improvement (*PT Routing*)

- Public Transport Scheduling Improvement (*PT Scheduling*)
- Public Transport User Incentive (*PT User Incentive*)
- Public Transport Information Service (*PT Information*)
- Public Transport Management Centre (*Management Centre*)
- Sidewalks and Crossing Facilities (*Pedestrian Facilities*)
- Non-motorised Transport Zone (*NMT Zone*)
- Non-motorised Transport Information Service (*NMT Information*)
- Vehicle Taxes and Duties for IMVs (*Taxes and Duties*)
- Vehicle Registration Control (*Registration Control*)

- **Effectiveness Compatible Assessment**

To Ensure Urban Mobility

The combination of five public transport measures in the package complementarily ensures that the highest capacity transport service is *available, affordable, accessible, and efficiently coordinated*. The same effect is expected in the case of three NMT measures in promoting NMT use. The implementation of *Taxes and Duties* and *Registration Control* together ensures that IMV use is discouraged by cost (vehicle purchasing and operation) and vehicle characteristics.

The inclusion of three NMT measures is helpful to ensure good physical access to public transport service, while the availability of public transport service ensures the supply for the NMT-inefficient trips of the NMT users. Combined implementation of these public transport and NMT measures helps to optimally define where the most suitable network routing and locations of public transport stops/stations are in order to support the NMT zones.

On the one hand, the implementation of *Taxes and Duties* and *Registration Control* forces a portion of IMV drivers to shift from IMVs to use public transport and NMT. On the other hand, the implementation of public transport and NMT measures ensures that the affordable and accessible transport services are available for the exiled IMV drivers, who were forced to stop driving either by high tax and duty or by vehicle registration constraints.

To Ensure Urban Traffic Safety

As described in Chapter Five, shifting travel demand from IMVs to public transport and NMT is the major impact on ensuring urban traffic safety in MDCs, especially in the situation of low safety awareness society. Similar to the compatibility in ensuring urban mobility, all measures are complementary in ensuring traffic safety. Implementation of five public transport measures ensures that the safest motorised transport service is available, affordable and accessible. The same complementary impact also encourages the use of NMT modes by implementing three NMT measures. Traffic safety is also improved by the barriers from using IMVs created by implementing *Taxes and Duties* and *Registration Control*.

The inclusion of three NMT measures reserves the safe access to public transport service, while the public transport measures ensures the safe transport mode for long distance trips, which will not be efficient if travelling by NMT.

The availability of affordable and efficient public transport and NMT services is a key condition to impose strict control of vehicle registration and high rates of vehicle taxes and duties on IMVs in order to reduce IMV use and further to reduce IMV related traffic accidents.

To Protect Urban Environment and Resources

The main impact on protection of environment and resources is shifting of travel demand from IMVs to public transport and NMT, especially the later transport mode. Although public transport service in MDCs is bus based and most of the buses use diesel, the combination of any two of these five measures will create much better impact on protecting environment and resources than individual implementation of any measure.

The same way of support can also be expected from implementation of three NMT measures or two IMV measures together in a package. The inclusion of three NMT measures is very important for the environment of the high-density centres and the two-wheeler accessed only blocks. In addition, this integration helps to improve physical access to public transport service. The implementation of two IMV measures and their desired achievement on protecting environment and resources can be successful if good alternative transport services are available. Therefore, implementation of *Taxes and Duties* and *Registration Control* in the package with the mentioned public transport and NMT measures is the most effective approach.

To Improve Economy of the City and Region

Again, the shift of travel demand from IMVs to public transport and NMT is accounted as the main impact on reducing passenger transport cost. At first, implementation of five public transport measures together helps to reduce significantly the travel time and distance of public transport passengers, while the combination with three NMT measures helps to reduce the access time to the public transport services. Secondly, NMT users will be assured that they can save much time for the long distance trips by using the public transport service. Thirdly, the direct impact on reducing IMV use by the implementation of *Taxes and Duties* and *Registration Control* helps the city and region avoid heavy investment on IMV industry, which is no more considered as a competitive one in comparison with other industries, such as garments and electronic parts, in both financial interest and job creation. Finally, implementation of these ten measures in a package helps to achieve an overall impact on improving the economic attractiveness of the city and region by good environment, cheap and accessible transport service.

- **Applicability Compatible Assessment**

Cost

On one hand, the combination of measures would simply add their investment costs into a bigger total amount. On the other hand, the combination of measures into the strategy helps to reduce some study and execution costs. Moreover, the investment on one facility and equipment can be efficiently used for different measures. Considered as a cost conflict, the inclusion of *PT user incentive* and *Management Centre* brings into the package a high level of difficulty in terms of operation cost. In contrast, the inclusion of *Taxes and Duties* definitely helps to finance the total cost of *PT user incentive* and *Management Centre* and of other measures. Therefore, the package is financial feasible and all ten measures are still recommended without obliged requirement of additional Conflict-Solving Measures.

Required Technical Systems

In general, the combination of measures will be a good condition to upgrade or newly provide complex required technical systems with synchronous technology, which helps to avoid the technical conflicts between old and new systems. Considered as a conflict, the inclusion of *PT Scheduling, Management Centre,* and *Pedestrian Facilities* brings into the strategy package the medium level of difficulty in required technical systems. In contrast, the inclusion of two information measures (*PT Information* and *NMT Information*) helps other ones overcome any difficulty created by required information systems in their implementation. Therefore, general level of difficulty in implementation in this barrier of the strategy is scaled down significantly.

Institutional Participation

In terms of transport related institutions, integration of the five public measures requires the participation of two groups, transport authorities and public transport operators. The inclusion of three NMT measures requires a lower level of difficulty with only transport authorities. The inclusion of *T*axes *and Duties* requires participation of traffic police not only as the enforcer but also as the operator of vehicle registration. Similarly, the inclusion of *T*axes *and Duties* and *Registration Control* asks for approvals of national decision-making institution, or high level of difficulty in this barrier. Therefore, integration of all ten measures will face a high level of difficulty in both transport related and political institutional participation.

Transport related institutions normally prefer the inclusion of *T*axes *and Duties*, which will provide finance to maintain the functions and other activities of the institutions. However, this measure encounters difficulties in getting the approval from the national decision making bodies, which are normally driven by lobby forces of the IMV manufacturers and businesses. Therefore, specific measures improving institutional participation are required, as well as the lobby measures in order to get approvals of national decision making institutions.

Public Acceptance

In getting acceptance of users, the level of difficulty could be increased to high level if *T*axes *and Duties* would be included. The inclusion of *NMT Zone* and *Registration Control* also adds considerable challenges in getting acceptance of users. On the other hand, the inclusion of *Pedestrian Facilities* is a large scale and a comprehensive project will face a strong opposition of the frontage land users (non-users), who have to resettle or relocate their properties to provide sufficient space for ensuring safe, smooth and continuous network of sidewalks. In this case, inclusion of *T*axes *and Duties* will be very helpful to provide financial compensation to the exiled land users and also to finance partly the cost of providing new social infrastructure for the new placements of land users. In addition, specific public education and awareness improvement measures are required in order to get acceptance of the land users.

6.3.2. Supportive Measures

- **Proposed Supportive Measure**

Considering the main barriers and conflicts in implementation of the Basic Measures, only *Signalisation of Intersection Control* (*Signalisation*) is the possible measure, which will help to ease the difficulty in required technical systems.

- **Compatibility Between Supportive and Basic Measures**

On the way to achieve four goals of urban transport systems by traffic shifting impact, the inclusion of *Signalisation* does not create considerable negative impact on the effectiveness of the Basic Measures. In contrast, the inclusion of *Signalisation* would possibly create positive impact on the achievement of all four goals, urban mobility, traffic safety, and environmental friendly and economic improvement. However, the main impact of *Signalisation* is controlling traffic, therefore, the compatibility in terms of effectiveness will not be further assessed.

Cost

The implementation of *Signalisation* simply adds its investment cost to the total amount of package. However, the inclusion of *Signalisation* in the strategy will eliminate all investment and operation costs relating provision and modification of traffic signal control in the other measures. Moreover, the inclusion of *Taxes and Duties* as a Basic Measure of the strategy can ensure that the increase of total cost by implementing *Signalisation* is covered.

Required Technical Systems

The most important supportive impact of *Signalisation* to the Basic Measures in the Traffic Shifting Strategy is to ensure that the required traffic signal control facilities at intersections are provided to support the implementation of *PT Scheduling*, *Pedestrian Facilities* in an urban scale requirements and other measures in local modifications of traffic operation and control systems.

Institutional Participation

The addition of *Signalisation* does not create any higher level of difficulty in the required participation of the institutions. In contrast, the *Signalisation* encourages the supports of traffic police for implementation of the strategy package by reducing number of traffic police officers, who have to manually control the traffic at non-signalised intersections.

Public Acceptance

The inclusion of *Signalisation* does not create any higher level of difficulty in getting acceptance of both groups of users and non-users. In contrast, it may be part of the offset benefit to bargain with the public in order to get their acceptance for the strategy as a complete package.

6.3.3. The Strategy Package

The Traffic Shifting Strategy includes desirably ten Basic Measures, which are five public transport measures (*PT Routing, PT Scheduling, PT User Incentive, PT Information, Management Centre*), three NMT measures (*Pedestrian Facilities, NMT Zone, NMT*

Information), and two IMV measures (*Taxes and Duties, Registration Control*). The inclusion of *Taxes and Duties, Registration Control* is highly difficult by requiring approvals of the national decision making institutions. In contrast, the inclusion of *Taxes and Duties* provides a potential source of revenue for financing the costs of other measures. Therefore, specific political lobby measures are required in order to have *Taxes and Duties, Registration Control* in the package.

In the list of first priority measures, only *Signalisation* is suitable to be Supportive Measure. The implementation of *Signalisation* provides all required intersection operation and control systems, which are essentially required for implementing the Basic Measures of the strategy.

6.4. Traffic Controlling Strategy

6.4.1. Basic Measures

- **Proposed Basic Measures**

As presented in the list of first priority measures, controlling traffic stream is the primary impact of five measures. The proposed combination of these measures creates an integration of traffic control impacts on transport infrastructure (*Pedestrian Facilities, Signalisation, Traffic Calming*), vehicle (*Registration Control*) and users (*Traffic Information*). Some other measures have traffic controlling as secondary impact, but the inclusion of them, as Basic Measures, may change the nature of the Traffic Controlling Strategy.

- **Effectiveness Compatible Assessment**

To Ensure Urban Mobility

The combination of these five measures ensures that all traffic participants (IMVs, NMT, public transport) and components (vehicles, users, infrastructures) are considered on the way to achieve the mobility impact of traffic control: proper right of way (at intersection areas, and on the road links) is used by proper users (in terms of mode, vehicle capacity and quality). The inclusion of *Pedestrian Facilities* and *Signalisation* ensures that pedestrian traffic is controlled, while *Traffic Calming* ensures the controlled and harmonise traffic speeds of different vehicles. Inclusion of *Registration Control* will exclude the extreme vehicles, which are too fast or too slow, too big or too small, too heavy or too old, in order to improve the unity of vehicle fleet, thus to optimise the operations of road space and vehicles themselves. Finally, the integration of *Traffic Information* ensures that all traffic users are provided with sufficient information before and during their trip.

One may recognise the conflict between *Signalisation* and *Traffic Calming*, but proper speed selection and imposition can simply avoid such conflict. For example, a speed limit between forty to fifty kilometres per hour is suitable for all urban arterials in MDCs; while a thirty tempo is well for other roads, which serve dense and mixed land uses in the city centres. A fifteen tempo is suitable for alleys in the two-wheel accessed only blocks.

To Ensure Urban Traffic Safety

As mentioned above, the combination of these five measures ensures that all safety aspects of traffic control (safe separation, less conflict, well awareness) are considered. The inclusion of *Pedestrian Facilities* and *Signalisation* ensures that pedestrians are protected longitudinally and horizontally. The combination of *Signalisation* and *Traffic Calming* improves the safety condition for bicycle traffic by minimising conflicts at intersections and on the road links. The implementation of *Registration Control* protects drivers from the accident potential vehicles, while good traffic-awareness is provided by *Traffic Information*.

To Protect Environment and Resources

The combination of five measures helps to achieve optimal smooth traffic flows on carriageways and sidewalks of the urban roads in MDCs. This maximizes environmental improvement of the controlling impact by minimizing the unplanned interruptions on the traffic flows. Combination of *Pedestrian Facilities* and *Signalisation* ensures that longitudinal movements of pedestrians and vehicles are separated, while their crossing-movements are controlled.

Traffic Calming ensures a proper range of speeds, in which most of the vehicles on the road can be operated smoothly. The implementation of *Registration Control* excludes most of environmental unfriendly vehicles, while *Traffic Information* guides the drivers to avoid the potential congestion areas, wherein their travel will produce more pollution and consume more fuel than the others.

To Improve Economy of the City and Region

The contribution of transport system in urban economic attractiveness is indicated by the ensuring safe accessibility to all land uses in the targeted and surrounding areas. By combining these five measures, traffic flows of all transport modes are controlled smoothly and properly. The inclusion of *Pedestrian Facilities* and *Traffic Calming* ensures safe accessibility to residential, educational, shopping and tourist areas, while commercial vehicular traffic is smoothly controlled by *Signalisation* and *Registration Control*. The low economic efficient trips can be avoided by providing sufficient *Traffic Information*.

- **Applicability Compatible Assessment**

Cost

In principle, the combination of these measures will sum up a total amount that must be bigger than the cost of single measure, thus creating a cost conflict. Therefore, financial resource is required in dealing with the cost conflict. However, the combination of measures will help to reduce the study and execution costs. Moreover, the inclusion of MIM3 and MIM5 in the strategy package simply eliminates the cost of improvements and modifications of technical systems, which are required in implementation of other measures.

Required technical systems

As mentioned above, the most important required technical systems for all five measures are already included in the package, *Pedestrian Facilities, Signalisation,* and *Traffic Calming*. Therefore, no conflict is expected to be solved in this combination.

Institutional participation

The combination of five measures does not bring in high level of difficulty in terms of transport related institutions. Like required institutional participation of *Signalisation* or *Traffic Information* individually, the package of five measures requires the participation of two groups, transport authorities, and traffic police. On the other hand, the inclusion of *Registration Control* requires approvals of the national decision making institutions. Therefore, specific lobby measures are required in order to get such approvals.

Public acceptance

Although the combination of five measures does not face a high level of difficulty in getting acceptance of transport users, the opposition of potential exiled land users (non-users) in *Pedestrian Facilities* is highly difficult and so specific Conflict-Solving Measures are required. On one hand, the human and business resettlement measures are preferred in dealing with such conflict. On the other hand, sufficient finance is required for compensation of the changes and for provision of social infrastructures at the new locations.

6.4.2. Supportive Measures

- **Proposed Measures**

Between two conflicts of the combination, the cost conflict is possibly solved by inclusion of *Taxes and Duties* as a Supportive Measure. The other conflict requires specific non-traffic management measures, which are not considered in the framework of this chapter.

- **Compatibility between Supportive and Basic Measures**

On the way to achieve four goals of urban transport systems by traffic controlling impact, the application of *Taxes and Duties* would create a very strong traffic shifting impact, thus the mere traffic controlling impact cannot remain. The implementation of *Taxes and Duties* would also create serious congestion if the public transport services were already overcrowded and the NMT facilities were in shortage. Moreover, very strong opposition from IMV drivers would be created by the inclusion of *Taxes and Duties* plus other Conflict-Solving Measures.

6.4.3. The Strategy Package

The Traffic Controlling Strategy includes desirably five Basic Measures, which are one non-motorised transport measure (*Pedestrian Facilities*), one measure for individual motorised vehicles (*Registration Control*), and other three multimodal measures (*Signalisation, Traffic Calming* and *Traffic Information*).

In terms of effectiveness, the measures are complementary in all four goals. However, with regard to the applicability, the inclusion of *Pedestrian Facilities* brings to the package a high level of difficulty in getting acceptance of the land users, especially the people who have to resettle their home or business.

In addition, the inclusion of *Registration Control* is highly difficult by requiring approvals of the national decision making institutions. In solving such conflict, IMV3 is the only available traffic management measure (in the first priority group), which can support by financing the cost of measures and to provide compensation for the exiled land users. However, the distortion of traffic impact by *Taxes and Duties* is the main reason for rejecting this measure.

6.5. Integrated Traffic Management Strategy

6.5.1. Basic Measures

- **Proposed Measures**

As defined in Chapter Two, integrated traffic management strategy aims to influence urban transport system in more than a single primary impact. Therefore, one can formulate theoretically four different strategy combinations. Firstly, a typical integrated traffic management strategy (ITMS) aims to impact on urban transport system in all three areas: to avoid traffic, to shift traffic and to control traffic. Secondly, one can formulate also three other reductive versions of ITMS, which are the traffic avoiding and shifting strategy, the traffic avoiding and controlling strategy, the traffic shifting and controlling strategy. In the framework of this chapter, a typical ITMS is formulated from all Basic Measures in the first priority group of measures (see Table 6-1).

- **Effectiveness Compatible Assessment**

To Ensure Urban Mobility

The integration of the fifteen measures ensures all objectives of urban mobility. At first, the implementation of *Land Use Change* and *City Logistic* will reduce a portion of total travel demand by combining the urban activities and then the logistic demands. The implementation of all five public transport measures ensures that the highest capacity transport service is available, accessible, affordable and well informed. The inclusion of three NMT measures reserves safe and informed environment for NMT users and improves physical access for the public transport service. The productivity of overall road network is also efficiently improved by the implementation of *Signalisation, Traffic Calming* and *Traffic Information*. These three measures also improve traffic quality of unavoidable the IMV trips. The implementation of *Taxes and Duties* and *Registration Control* may prevent some drivers from driving, but their travel demand can be efficiently performed by public transport and NMT, which are significantly improved by the other measures of the strategy.

To Ensure Urban Traffic Safety

The expected impact on traffic safety of traffic management is reduction of the IMV trips, which are defined in figures as the highest accident possibility trips in MDCs and in all over the world. The implementation of traffic avoiding measures (*Land Use Change* and *City Logistic*) will reduce absolutely travel demands, thus reducing conflicts generally and severe conflicts particularly. The improvements of public transport services and NMT facilities in terms of availability, accessibility, affordability, and information would attract and serve most of urban travellers, including many current IMV drivers.

The shifting from IMV to public transport and NMT also stresses the inclusion of *Taxes and Duties* and *Registration Control*, which reduces affordability (*Taxes and Duties*) and accessibility (*Registration Control*) of IMV drivers. Moreover, *Registration Control* eliminates the unsafe vehicles (e.g. too big, too small, too old) from the urban traffic. The most deadly conflicts on the road would be reduced and eliminated (desirably) by the implementation of *Signalisation* and *Traffic Calming*, while the unsafe traffic locations would be avoided by drivers with the implementation of MIM6. Returning to the other main impact of *City Logistic*, the reduction of heavy truck trips in the urban roads definitely reduces frequency of accidents, especially the high fatality accidents between trucks and motorcycles in MDCs.

To Protect Urban Environment and Resources

Implementation of the strategy, urban environment and resources are protected by reducing (1) sources of pollution and fuel consumption, (2) rates of pollution and fuel consumption per transport production unit (person-kilometre, ton-kilometre), (3) rates of pollution and fuel consumption per traffic production unit (vehicle-kilometre).

Firstly, the implementation of NMT measures, IMV measures, *Land Use Change* and *City Logistic* reduces absolutely the needs and the possibility to operate motorised vehicles, which definitely produce pollution and consume fuel.

Secondly, the implementation of public transport measures will reduce the rates of pollution and fuel consumption per person- trip or per person-kilometre by shifting travel demand from using IMVs to public transport service.

Finally, implementation of *Signalisation* and *Traffic Calming* ensures a smooth and less interrupted vehicular traffic flow, thus reduces rate of pollution and fuel consumption per vehicle trip or vehicle-kilometre.

To Improve Economy of the City and Region

In developing countries, the contribution of urban transport system in improvement of the city and region economy means to encourage investors to create economic activities there by ensuring the good accessibility to every land uses in the city or region. The implementation of this ITMS would be an efficient package of transport solution for the city and region in improving its economy. *Land Use Change* aims to condense the urban activities in designated areas and also to optimise the economic benefit of the urban space by grouping the mutual supportive land uses, for example combining of residential, shopping, schooling and health care activities in one area. The implementation of *City Logistic* ensures that all good transport demands are optimally served. Good public transport services and NMT facilities, smooth traffic flow attract the employees to settle and the employers to do businesses. The tourist businesses, services, and cultural events can also benefit from the improvement of public transport services and NMT facilities.

- **Applicability Compatible Assessment**

Cost

Like other strategies, combination of fifteen measures will sum up the costs to a very big total amount in both investment and operation, thus creating a cost conflict. The inclusion of *Taxes and Duties* can be the first solution to deal with this conflict. Moreover, one can expect that a proper design of *Taxes and Duties* can be very effective in inter-financing the other measures in the strategy. The other benefit of combination is the elimination of all costs for improving and modifying traffic signal control system and information systems of all modes if each measure would be implemented individually. The combination of urban space required measures (*Pedestrian Facilities, NMT Zone, Land Use Change, City Logistic*) at once would help to minimise the need of land area, thus, reducing the land acquisition cost and the resettlement compensation as well. Finally, the combination of measures helps to reduce study cost.

Required Technical Systems

One of the key benefits in combination of the measures is to combine technical requirements of all measures in one package and to solve by the *Signalisation, PT Information, NMT Information*, and *Traffic Information*. In most of MDCs, these four measures address virtually all issues of required technical systems in the urban transport.

Institutional Participation

The combination of fifteen measures definitely brings the requirement of institutional participation to the highest level. At the level of implementation, transport authorities, police and operators are required to cooperate, while the national decision making institutions are required to issue their approvals for *Taxes and Duties* and *Registration Control*. For the transport related institution, legalisation of Traffic Management Plan as one of plans in the urban transport planning process should be the best conflict solving solution. This would decide an obligation of institutional participation in implementing traffic management measures and strategy, especially for transport authorities and polices. The difficulty in dealing with national decision-making bodies would require specific political lobby measures.

Public Acceptance

The integration of fifteen measures faces a high level of difficulty in terms of public acceptance. The traffic users, mainly IMV drivers, definitely oppose the implementation of *NMT Zone* strongly. Many IMV drivers also make noise with the inclusion of *NMT Zone* and Registration Control. However, the implementation of public transport and NMT measures can be a concrete part of solution for this conflict by providing to many IMV drivers cheaper, safer and substitutable transport alternatives.

For the non-users, especially the affected land-users, they are definitely unhappy to relocate their home and business by implementing of *Pedestrian Facilities, NMT Zone, Land Use Change* and *City Logistic*. The IMV manufacturers and service suppliers would also oppose the implementation of IMV3. However, this measure is the key source to finance the investment and operation cost of other measures. Moreover, this measure is also a concrete part of solution in dealing with the resettlement and relocation conflict. As mentioned above, the *Taxes and Duties* is preferred to be included to achieve the traffic avoiding impact and to get financial resource.

6.5.2. Supportive Measures

- **Proposed measures**

As discussed above, the combination of measures in an ITMS faces a high level of difficulty in three out of four applicability criteria, thus, requiring Supportive Measures in order to overcome such conflicts. As defined above, the ITMS includes already fifteen measures in the first priority list. Therefore, the Supportive Measures are looked from the lower priority groups.

Firstly, the summation of investment and operation cost requires a big amount of money to provide and maintain the impacts of all measures. Although the inclusion of *Taxes and Duties* can be considered as an important financial source, the revenue from IMV taxes and duties is also required for financing other parts of urban transport system of the targeted city (e.g. new roads or parking facilities) and to finance transport systems in other cities and provinces of the country. Therefore, the cost conflict still requires other solutions. However, examining all other traffic management measures, only *Road Pricing* and *Parking Pricing* are potential Supportive Measures for providing additional financial resource.

Secondly, the strategy faces a high level of difficulty in getting participation of both groups of institutions. Unfortunately, none of the other nineteen measures can help to eliminate this conflict. Therefore, specific legal improvement and political lobby measures are required to overcome the barriers.

Thirdly, the high level of difficulty in getting public acceptance is not able to overcome by any traffic management measures among the list of fifteens or thirty fours, except some financial compensation for resettlement can be expected from inclusion of *Taxes and Duties* and then *Road Pricing* and *Parking Pricing* if they are included as financial Supportive Measures.

Therefore, two other traffic management Supportive Measures, *Road Pricing* and *Parking Pricing*, are proposed to be part of the strategy.

- **Compatibility between Supportive and Basic Measures**

In terms of effectiveness, the addition of *Road Pricing* and *Parking Pricing* will not create any negative impact on the way achieving of the strategic goals of urban transport system. In addition, the support of these two measures in solving the cost conflict is already clearly defined as the main reason to include them in the strategy package. The following discussions focus on three other criteria of applicability.

Required Technical Systems

These two measures, *Road Pricing* and *Parking Pricing,* do not bring in any new requirements on technical systems. Moreover, the inclusion of *Signalisation, PT Information, NMT Information*, and *Traffic Information* prevails most of basic technical systems to implement any new measures. Therefore, no conflict is expected in this aspect.

Institutional Participation

The most worrying issue is the required approvals of the national political bodies for implementing *Road Pricing*. However, this inclusion does not increase the difficulty level in this barrier because such a high level is already there for implementing IMV3. The inclusion of *Parking Pricing* requires only approvals of the city level.

Public Participation

In this barrier, counter force of car drivers is counted for the implementing of *Road Pricing*. However, the number of car drivers is still a very small portion in MDCs, therefore, this counter force can be ignored. However, the opposition of all IMV drivers must be considered in the implementation of *Parking Pricing*. However, the force is reduced with the provision of reliable transport alternatives (public transport and NMT). On the other hand, the counter force of non-users can be ignored because the implementation of *Road Pricing* and *Parking Pricing* does not create any barrier on vehicle purchasing, but only on using.

- **Compatibility between Supportive Measures**

With regard to both effectiveness and applicability, no conflict is expected if *Road Pricing* and *Parking Pricing* would be simultaneously implemented as the financial Supportive Measures of the integrated traffic management strategy. Moreover, the implementation of these two measures would yield a better impact on reducing the use of IMVs, thus encouraging IMV drivers to use public transport services and NMT modes.

6.5.3. Strategy Package

The integrated traffic management strategy includes seventeen traffic management measures. Fifteen Basic Measures are expected to influence urban transport system in all three areas: to avoid traffic, to shift traffic, and to control traffic. The combination of these Basic Measures definitely yields a high level of effectiveness, but it also faces high level of difficulty in three barriers in implementation. The cost conflict is partly solved by inclusion of I *Taxes and Duties*, but the revenue from this measure need to be spent on other needs, especially the financial needs of transport systems in the cities or provinces other than the targeted one. Fortunately, the inclusion of other two economic measures, *Road Pricing* and *Parking Pricing* as financial Supportive Measures for the strategy was recommended. The assessment also proved that no considerable conflict was raised by the inclusion of these two measures. However, the conflicts in getting required institutional participation and public acceptance still require the Conflict-Solving Measures, which are not parts of the traffic management measures. Specific legal improvements and political lobby would be required in order to overcome such difficulties.

6.6. Conclusions

This chapter presents the structure and process of the strategy formulation model and the application of this model in formulating four typical traffic management strategies.

- **The Strategy Formulation Model**

The first step aims to select the most suitable ***Basic Measures***, whose implementation is the major efforts in solving urban transport problems. The second step is to define the ***Supportive Measures***, which aims to improve applicability or to reduce the level of difficulty in implementing Basic Measures. In many cases, conflicts cannot be solved by traffic management measures, thus requiring additional non-traffic management measures, so called ***conflict-solving measures***.

Defining Basic Measures

The Basic Measures are proposed based on the primary traffic impact (to avoid, to shift and to control traffic) of the measures in the first priority list. Compatibility between Basic Measures is assessed by two groups of criteria, *effectiveness* and *applicability*. *Effectiveness compatible measures* support each other to increase the level of achievement of the strategic goals. *Applicability compatible measures* help each other to reduce the level of difficulty of barriers in application.

Defining Supportive Measures

The candidate Supportive Measures are firstly selected from the first priority measures. Although improvements of effectiveness are not concerned, the candidate measure will be simply excluded if it tends to create negative impact on effectiveness of the Basic Measures. The applicable compatibility between proposed Supportive Measures and the Basic Measures in the applicability aspects is qualitatively assessed.

Specific Conflict-Solving Measures

Many conflicts cannot be solved by traffic management measures, thus requiring specific non-traffic management measures. Three groups of Conflict-Solving Measures will be proposed according to the conflicts between Basic Measures (B&B), between basic and Supportive Measures (B&S), and between Supportive Measures (S&S).

- **Traffic Avoiding Strategy**

This strategy in MDCs consists of two traffic management measures, *Land Use Change* and *City Logistic*, which are defined as the Basic Measures of the strategy.

In terms of effectiveness, the combination of these two measures is complementary in improving the urban mobility, traffic safety, urban environment and economy by absolute reduction of passenger and good transport demand.

In terms of applicability, the combination will sum up a considerable total cost, but the main part of this cost will be paid by the private investors. Although, the combination does not face significant technical or institutional difficulty, it must overcome a high level of difficulty in getting acceptance of the impacted land users.

- **Traffic Shifting Strategy**

This strategy includes desirably ten Basic Measures, which are five public transport measures (*PT Routing, PT Scheduling, PT User Incentives, PT Information, Management Centre*), three NMT measures (*Pedestrian Facilities, NMT Zone, NMT Information*), and two IMV measures (*Taxes and Duties, Registration Control*).

In terms of effectiveness, the combination of these measures is complementary in improving the urban mobility, traffic safety, urban environment, and economy by shifting travellers from using IMVs (mainly motorcycles) to public transport and non-motorised transport modes. The cost conflict by summing up individual measure costs is effectively solved by the inclusion of *Taxes and Duties*.

The integration of all ten Basic Measures faces a high level of difficulty in both transport related and political institutional participation. Therefore, specific measures for improving transport institutions' awareness and participation are required, as well as the lobby measures in order to get approvals of national decision making institutions. Specific human and business resettlement measures are required to ease the difficulty in getting acceptance of the impacted land users.

In assessing the capability of Supportive Measure, the implementation of *Signalisation* provides all required intersection operation and control systems, which are essentially required for implementing the Basic Measures of the strategy. No new conflict in implementation is expected from the inclusion of *Signalisation* in the strategy.

- **Traffic Controlling Strategy**

This strategy includes five Basic Measures, which are one non-motorised transport measure (*Pedestrian Facilities*), one measure for individual motorised vehicles (*Registration Control*), and other three multimodal measures (*Signalisation, Traffic Calming, Traffic Information*).

In terms of effectiveness, the combination of these measures is complementary in improving the urban mobility, traffic safety, urban environment, and economy by controlling three components of urban traffic (infrastructure, vehicle and travellers).

In terms of applicability, the summation of costs is the main conflict of the combination requiring financial Supportive Measure. In addition, the inclusion of *Pedestrian Facilities* brings to the package a high level of difficulty in getting acceptance of the impacted land users. The inclusion of *Registration Control* also faces a high level of difficulty by requiring approvals of the national decision making institutions.

- **The Integrated Traffic Management Strategy**

The strategy includes seventeen traffic management measures. Fifteen Basic Measures are expected to influence urban transport system in all three areas: to avoid traffic, to shift traffic, and to control traffic.

In terms of effectiveness, the combination of these measures is complementary in improving the urban mobility, traffic safety, urban environment and economy by all three major traffic impacts, avoiding travel demand, shifting travellers from using IMVs (mainly motorcycles) to public transport and non-motorised transport modes, and controlling traffic performance.

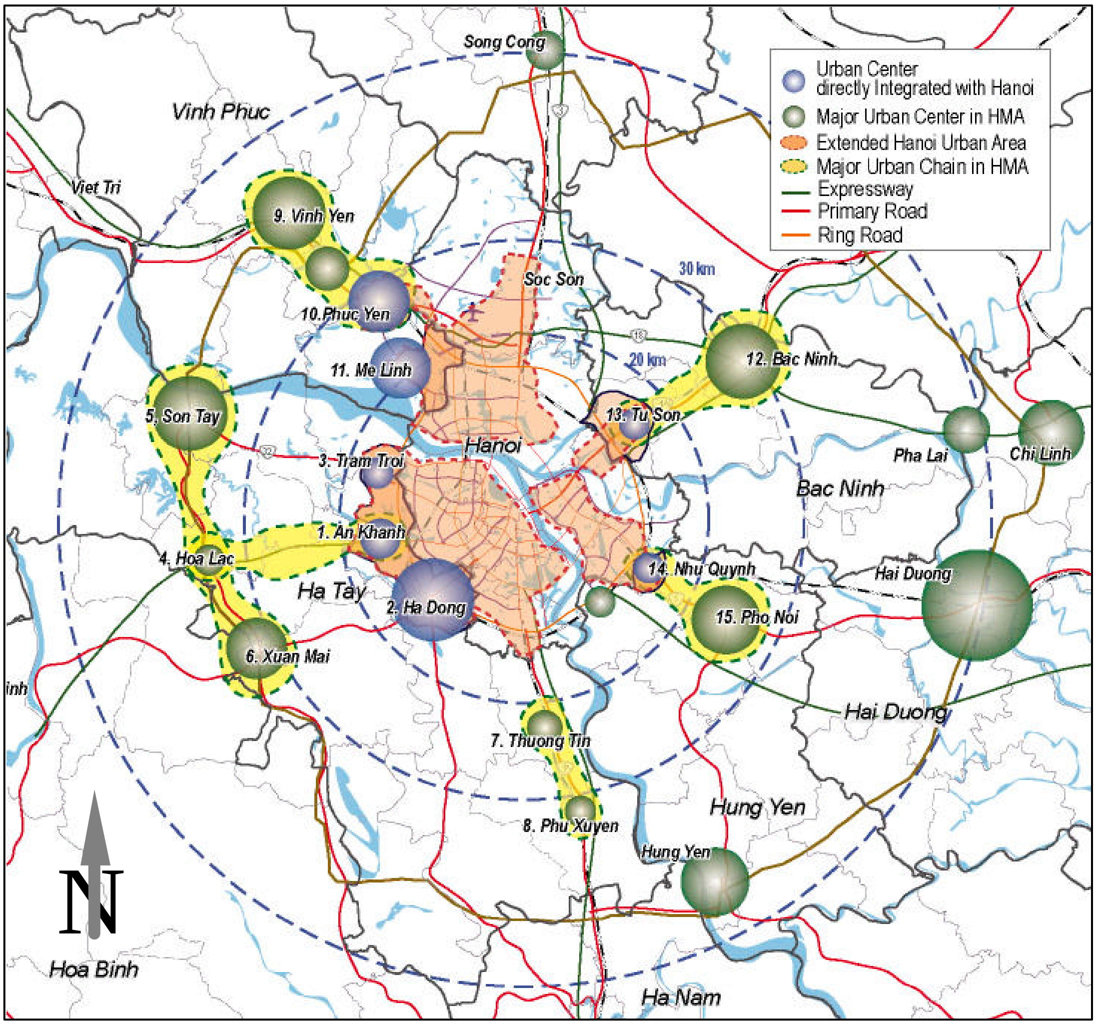
In terms of applicability, the combination faces a high level of difficulty in three barriers. The cost conflict is partly solved by the inclusion of *Taxes and Duties*, but the revenue from this measure has to be spent on other needs, especially the financial needs of transport systems in the cities or provinces other than the targeted one.

Road Pricing and Parking Pricing are selected as financial Supportive Measures for the strategy. However, the conflicts in getting required institutional participation and public acceptance still ask for specific legal improvement and political lobby measures.

7. Proposal for Application in Hanoi

7.1. Introduction

In 1010, Hanoi was declared as the capital of Vietnam by first feudal emperor of Vietnam, Ly Thai To. Since 1945, Hanoi is the capital city of the Democratic Republic of Vietnam as today the Socialist Republic of Vietnam. At present, Hanoi has a population of about 3 millions, 62,5% of which reside in the city's conurbation (JICA and HAPC, 2006). Hanoi covers an area of 921 square kilometres, which is divided into 14 districts (Quan) or 228 wards (Phuong). The city's conurbation covers an area of 102 square kilometres, including four central districts and other five urban fringe's districts.



[Source: from an unknown scale map of JICA and HAPC (2006)]

Figure 7-1: Hanoi and its satellites in the Hanoi metropolitan area

As the heart of the country's innovation process, Hanoi's economy has been growing consistently at 11% since 1995 and it will keep on the same track in the next decades (JICA and HAPC, 2006). Although Hanoi is still in the low-income city's group (GRP per capita was about US$ 1000 in 2003), the economic growth significantly improves the financial capability of the city. The Stalinist political system is replaced gradually by a new system, in which the market economy is developed under a mono-party political regime.

Located in the technology booming region (East Asia), Hanoi is also recognised as one of the fastest information and telecommunication (IT) development cities during the last five years, but the application of IT in transport sector is still at a low level. Although Hanoi is the host of about 50 universities and colleges and the number of graduates is booming, the quality of human resource is still a critical problem for Hanoi in all sectors.

In the cultural aspect, the increase of affordability and the globalisation brings in the new way-of-life, which creates both new social and cultural values and problems, especially the immaturity of human behaviours, for example the behaviours in owing and driving motorcycles and cars of Hanoians.

According to the statements in Chapter Three, Hanoi is a typical Motorcycle Dependent City, in which more than 50% of total urban personal trips are accommodated by motorcycles that account for more than 90% of total vehicle travelling on the road. The city also becomes notorious for the large number and severity of traffic accidents and traffic pollution. Although the urban transport demand is extremely high, the current trip time and travel speed are still at a reasonable level. However, traffic congestion and its consequences are growing quickly in accordance with the shifting of drivers from motorcycles to private cars.

In this chapter, the unique urban and transport image of Hanoi is printed specifically in section 7.2, in which the future development goals and objectives of urban transport system in Hanoi is also addressed. Section 7.3 discusses about the application of four major traffic management strategies, which were formulated in chapter 6. Finally, the discussion on applications the first priority traffic management measures is presented in section 7.4.

7.2. Existing Urban and Transport Conditions

7.2.1. Urban Development Conditions

- **Rapid Urbanisation and High Population Density**

Hanoi has a monocentric urban form, which focuses on the city centre covering the Ancient Quarter and the French Quarter. The city has been expanding quickly in both population and area. In 20 years (1984-2003), the urban population has been almost doubled, from 1 million to 1,9 millions, and the conurbation has been expanded as an oil-stain, from 57 kilometres to 102 kilometres. At the end of 2003, the population density of Hanoi conurbation was about 180 persons per hectare, while the rate in the centre's districts (Hoan Kiem, Hai Ba Trung, Ba Dinh, Dong Da) was 305 persons per hectare. This high-density contains both *opportunities* (e.g. compact land use) and *challenges* (e.g. extremely high transport demand).

- **Two-wheeler Accessed Only Blocks**

The uncontrolled urbanisation and the explosion of motorcycle use at the same time create many two-wheeler accessed only blocks in the conurbation of Hanoi. As found by the field survey in 2004, nearly 79% of Hanoi urban population are living in such type of residential blocks, where the access road is less than 5 meters width, called alley. The main issue of this unique urban form is the isolation from the public transport service and the emergency services (e.g. ambulance, fire fighter). Recently, traffic accidents and pollutions are also seriously concerned. However, within a period of 20 to 30 years, this unique urban form will remain largely in Hanoi.

Figure 7-2: Different urban forms in Hanoi city centre

7.2.2. Motorcycle Dependent Transport System

- **Rapid Motorisation by Motorcycle**

At the end of 2003, Hanoi had 1,2 million motorcycles (400 MCs per 1000 inhabitants) and about 36 thousand private cars. According to the field survey in 371 households in 2004, the share of motorcycles in the vehicle fleet has been grown up from 14,3% before the year 1985 to 75,2% after the year 2000. In contrast, the bicycle share has been reduced from 85,7% to 24,1% in the same period. The car ownership is still low (12 cars per 1000 inhabitants in 2003) but growing quickly, at the rate of about 15% per year.

- **Insufficient Infrastructure**

Lack of Urban Road

Currently, Hanoi has a total road length of 770 kilometres, which covers only 1,7% total city's area. Most of the roads are two-lane, undivided, and the alleys are never considered as part of urban road network and absent from urban road statistics absolutely.

Imbalance in Distribution and Incomplete Road Hierarchy

In the conurbation, the general road area density is about 6,18%, while the rate is 22,87% in the Ancient Quarter and French Quarter (TEDI, 2004). The road design standard is car-based and often inconsistent with the road function. The network is unconnected due to a lack of car-based distributor roads (JICA and HAPC, 2006).

Lack of Parking Facilities

According to Duy-Hung (2004) Hanoi needs about 200 hectare for public parking, but the current area is only 24,55 hectare divided into 6 off-street parking facilities (15,9 hectares), 123 on-street parking lots (7,4 hectares) and 350 motorcycle and bicycle parking lots (1,15 hectares). Some thousands of parking lots are operating temporarily illegally on the sidewalks, green-areas or even in the living houses of people. The unbelievably high price of land is the main and too difficult barrier against more space for parking.

- **Low Availability and Incompetent Public Transport Services**

Unstable Quality and Limited Capacity Bus Service

Until the end of June 2006, Hanoi public bus service has been operated by 863 buses, operating on 54 bus lines, and covering 1028 kilometres of route length (TRAMOC, 2006). The total number of transported passenger increased about 16 times between 2001 and 2004, from 16 millions to 255 millions, about 7% total travel demand (TRAMOC, 2005). Although the bus service is very successful in terms of productivity and service frequency, the operation quality is still low by running on the mixed traffic flow, in which the buses are competing for road space with motorcycles, bicycles, tricycles, trucks, and cars, and they frequently miss schedule. The buses are over-crowded, especially during peak hours, due to limited vehicle capacity.

Unregulated Paratransit Service

Paratransit service in Hanoi is supplied by two types of vehicle. Some 3000 ordinary taxis are operating in a quite high quality level, which is indicated by new vehicle and centralized operation. However, this service is too expensive for the normal Hanoians. About more than 15000 motorcycle taxis are serving as the main paratransit vehicle in Hanoi, but the service is provided individually and unregulated (JICA and HAPC, 2006). The tri-cycles and microbuses were the main paratransit vehicles before 1990, but it has been prohibited on the urban roads since 2000 (TEDI, 2004).

- **Less Developed and Ineffective Traffic Management**

Many traffic management measures have been implemented in Hanoi but their effectiveness is low due to two major reasons. The first reason is a lack of a comprehensive and clear traffic management concept. Traffic management measures are implemented by chance, mainly with foreign assistance or because of some additional measures for road or public transport development. The second is a lack of awareness of related institutions and other stakeholders about the impact of traffic management. Moreover, the authorities and politicians prefer infrastructure development projects to the traffic management ones.

Public Transport Measures

As mentioned above, the public transport measures (e.g. *PT Routing, PT Scheduling, PT users incentive etc.)* were implemented under a bus service reform project, in which the main targets were to merge three state-owned operators into one (TRANSERCO) and to buy a new bus fleet. *Paratransit regulation* is current effected only on ordinary taxi. Other vehicles are operating without proper regulation and control.

Non-motorised Transport Measures

The sidewalks are provided along most of the urban car-based road, as the required urban road design standard, but most of them are used for economic and parking activities, except those along few political demonstration streets. Bicycle lanes had also been introduced, but it failed quickly due to a lack of control and enforcement. Pedestrian crossing facilities are mostly ignored with regard to both provision and design. Night-time *pedestrian zone* was implemented since Dec.2004 on Hang Dao and Hang Ngang Street in the Ancient Quarter, but the impact is not significant.

Individual Vehicle Measures,

The Right-of-Way Reduction for Private Car was implemented in the form of one-way traffic for car only along some urban roads, while cars are using aggressively space for travelling and parking on the remaining part of urban roads. The *separation of motorcycles* from four-wheel- vehicles failed because of a lack of road space and enforcement. *Vehicle taxes and duties* are applied successfully in Vietnam in two major forms: vehicle import tax and vehicle registration fee system. No *Road Pricing* is applied for the urban road in Hanoi, but *Parking Pricing* is implemented ineffectively by a simple flat-rate form. *Vehicle Registration Control* for IMVs has been effectively implemented for a long time by the limitation of engine capacity.

Multimodal and Intermodal Transport Measures

The *Ringroad System* was introduced for the Ancient Quarter since 1995, but the effectiveness was low due to the adoption of a pair of one-way street through this area. The concept was extended overall city's conurbation with three levels ringroad system but as a road development measure. *Intersection signalisation* is applied for only 160 among nearly 600 signal-required intersections (JICA and HAPC, 2006). The impact on improving safety is high, but the simple two-phase, fixed-time controlling program is not highly effective on reducing congestion. Some roundabouts are applied in order to control traffic at few *non-signalised intersections*, but the difficulty in acquiring land does not allow extending this measure. The *speed reduction*, 50-tempo, is implemented uniformly under the road traffic law. However, the concept of t*raffic calming* is not yet considered. As a seldom-positive point, the integration between long-distance and urban transport is relatively good.

Freight Transport Measures

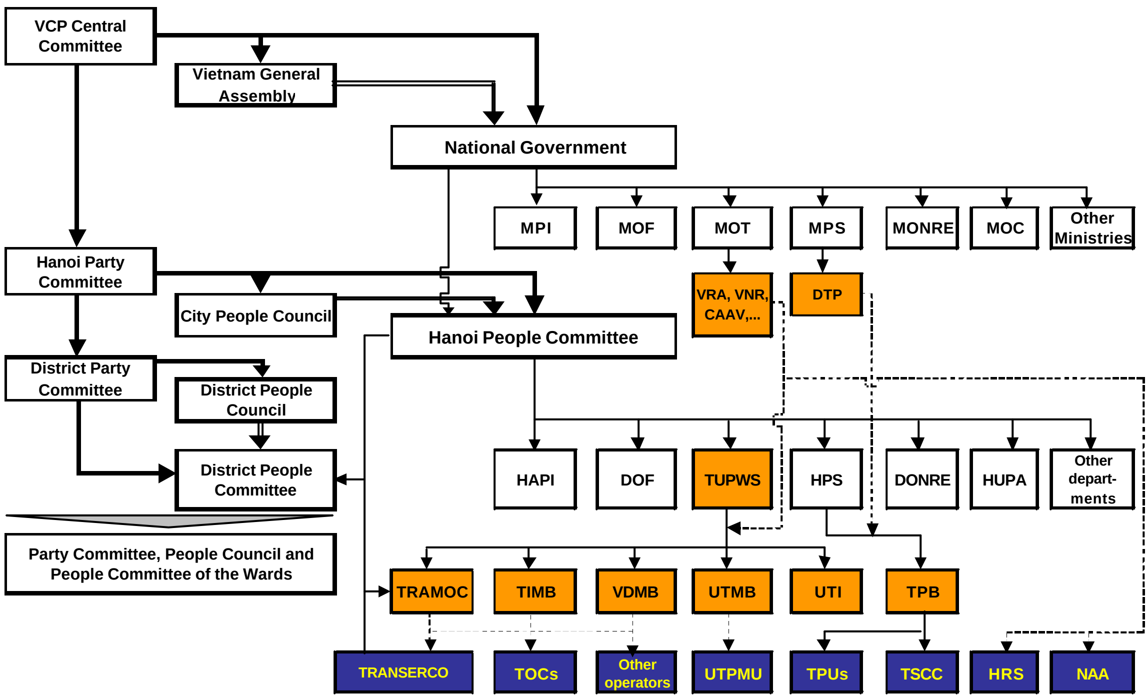
The *urban truck control* is effectively implemented by prohibiting heavy trucks (more than 3,5 ton) from daily operation in the city centre. The urban *logistic service* is providing discretely by the private sector in different small-scale business. The concept of *city logistic management system* is not yet introduced. The *freight taxi service* is effectively implemented in two forms: pick-up taxi and modified motorcycle taxi.

7.2.3. Institutional Structure in Hanoi

- **City Political Institutions**

The city political level consists of three institutions: Hanoi Communist Party Committee (Party), City People Council (People Council), and City People Committee (HAPC). As the design of the mono-party political system, the ***Party*** has an under-masked super power, which can interfere and change any decision of ***People Council*** or HAPC.

The ***People Council*** plays the role of major elected decision-making body for regulations and socio-economic development plans of Hanoi. However, the long-term development plans of Hanoi need further decision of the national political institutions (National Government) after getting approval of ***People Council***. Theoretically, the ***People Council*** is responsible for making decisions on the annual socio-economic development plans, city budgets, taxes and duties at the city level. In fact, the ***Party*** makes the final decisions.



Legend:

Political decision-making institutions; Functional administrative authority; Transport related authority in Hanoi; Transport and Traffic Operators

Superior political relation; Law-making functional relation; Administrative functional relation; Operative functional relation

VCP: Vietnam Communist Party
MPI: Ministry of Planning and Investment
MOF: Ministry of Finance
MOT: Ministry of Transport
MPS: Ministry of Public Security
MONRE: Ministry of Resources and Environement
MOC: Ministry of Construction

HAPI: Hanoi Department of Planning and Investment
DOF: Hanoi Department of Finance
TUPWS: Hanoi Transport and Urban Works and Services
HPS: Hanoi Department of Public Security
DONRE: Hanoi Department of Resources and Environement
HUPA: Hanoi Department of Urban Planning and Architechture
VRA: Vietnam Road Authority
VNR: Vietnam Railways Corporation
CAAV: Civil Aviation Authority of Vietnam
HRS: Hanoi Railway Station Company
NAA: Noibai Airport Authority

TRAMOC: Hanoi Urban Transport management and Operation Centre
TIMB: Transport and Industry Management Bureau
VDMB: Vehicle and Driver Management Bureau
UTMB: Urban Traffic Management Bureau
UTI: Urban Transport Inspection
TPB: Hanoi Traffic Police Bureau
TPUs: Traffic Police Units
TSCC: Traffic Signal Control Centre
UTPMU: Urban Transport Project Management Unit
TRANSERCO: Hanoi Transport Corporation
TOCs: Taxi Operation Companies

Figure 7-3: Institutional structure in Hanoi

The HAPC is issuing all administrative decisions to execute the long-term development plans, the annual socio-economic development plans, projects and other legal decisions of ***People Council*** and the national political institutions respect to Hanoi. The HAPC and its functional subordinates are responsible for preparation of the long-term development plans, annual socio-economic plans and the state-funded projects in the city scale.

The main issue of the city level political institutions is the overlapping between decision powers of ***Party***, ***People Council*** and HAPC. Especially, the super power of ***Party*** creates many disturbances and delays in executing the decisions of ***People Council*** and HAPC.

- **Transport Related Institutions**

Authorities

Under HAPC, Hanoi Transport and Urban Works and Services (TUPWS) and Hanoi Traffic Police Bureau (TPB) are two major governmental authorities directly related to transport sector.

In general, TUPWS is responsible for provision and maintenance of infrastructure and management facilities and equipments. TUPWS is also responsible for controlling the quality of transport and logistic service. As a semi-functional branch of TUPWS, Hanoi Urban Transport Management and Operation Centre (TRAMOC) is the authority dealing with public transport service. The Transport and Industry Management Bureau (TIMB) deals with regional passenger transport and urban good transport service. The Vehicle and Driver Management Bureau (VDMB) is responsible for the issues of vehicle standard control and driver licenses. The Urban Traffic Management Bureau (UTMB) deals with operating, maintaining and regulating urban transport infrastructure and traffic management facilities. The Urban Transport Inspection (UTI) is responsible for controlling all activities that related to the physical conditions of urban transport facilities.

As a functional branch of Hanoi Department of Public Security (HPS), TPB is responsible for traffic law enforcement and operation of traffic management urban traffic signal control centre (TSCC). The works of TPB are divided spatially for 10 traffic police units.

Transport Operators

Hanoi Transport and Service Corporation (TRANSERCO) is the main public transport operator in the urban area. Currently, this holding company operated 48 of 54 urban bus lines, all intercity bus stations, river's ports and off-street stated-owned parking facilities. For paratransit services, Hanoi has about 40 small companies, which operate ordinary taxi.

In the sector of goods transport and logistics, Hanoi has about 50 companies, which operate transport service and logistics centre. In addition, there are about 10 pickup taxies companies and thousands of individual truckers.

The intercity railway stations and the airport in Hanoi area are operated by Hanoi Railway Stations Company under the regulations of Vietnam Railways (VNR). The Airport is operated by Noi Bai Airport Authority and its companies (e.g. Noi Bai International Airport Ground Services) under regulations of Civil Aviation Authority of Vietnam (CAAV).

Issues of Transport Related Institutions

The main issue of transport authorities is lack of cooperation and coordination between TUPWS and TPB and between the bureaus within TUPWS. The other issue is overlaps in functions between TPB and TUPWS. Specifically, functions are overlapping between TPB and TUI in traffic enforcement, between TPB and UTMB in provision and operation of traffic control facilities, for example TCSS, and between TPB and VDMB in registration and controlling vehicle fleet. Inside the TUPWS, functions of different bureaus are also unclearly defined, especially the functional overlaps of TRAMOC and TIMB.

Between authorities and operators, the main issue is also the overlaps between functions, especially in planning and quality management. The other issues are corruption (of both sides) and lack of awareness about the missions and functions.

7.2.4. Vision, Goals and Objectives

In the Order of State President, the vision of Hanoi's future is addressed as ""the heart of the whole country, making it more and more beautiful, civilized and modern; to inherit and promote age-old historical and cultural traditions of Thang Long – Hanoi; to contribute in making the country more beautiful and prosperous".

As addressed in the Comprehensive Urban Development Programme in Hanoi Capital City (HAIDEP) four major goals transport system in Hanoi are addressed as follows:

- To establish an effective intermodal transportation system (including road, rail, air, inland water transport) and logistics services that are competitive in international/regional trade and passenger travel,
- To develop a comprehensive urban road network with optimal road hierarchy that includes primary, secondary, and tertiary road,
- To develop an efficient and high-quality public transport system, which would be a comprehensive combination between urban rail transit and the road based modes in order to be the main passenger transport service of the city,
- To establish an effective traffic management system, including proper maintenance, traffic control, parking management, safety improvement, pollution control, and pedestrian safety….(JICA and HAPC, 2006).

For the traffic management, two specific objectives are defined by HAIDEP: (i) *to enhance mobility, accessibility and safety*; and (ii) *support public transport for better effective services.*

The main issue of this goal-objectives structure is lack of a comprehensive strategic policy framework that integrates and orders the vision, goals and objectives. This has led to the absence of environmental and economical factors in formulating the strategic goals and objectives. The second issue is the overlap between two traffic management objectives. Therefore, the Strategic Policy Framework in Chapter Four is strongly recommended to apply to Hanoi.

7.3. Application of Traffic Management Strategies

7.3.1. Typical Traffic Management Situations in Hanoi

As described in the previous section and in Chapter Three, Hanoi is a typical motorcycle dependent city, in which the traffic management strategies are required to improve three major urban transport situations (subsequently **situation**) that are defined relatively by the spatial condition:

- Unbalanced urban transport system in overall city conurbation (subsequently **Conurbation**),
- Chaotic traffic on the urban arterials (subsequently **Arterial**)
- Heavy traffic congestion in the city centre (subsequently **City Centre**),
- Two-wheeler accessed only blocks (subsequently **Two-Wheeler Block**).

The brief descriptions about the situations are presented in the followings.

- **Conurbation**

According to HAIDEP, the conurbation of Hanoi is currently defined as the urban area within the third ringroad including all urban districts (JICA and HAPC, 2006). The urban condition and transport performance led Hanoi's conurbation to the three major traffic problems. High frequency and severity traffic accidents occur on both road links and intersections overall road network in the conurbation. Traffic congestions frequently occur on the urban arterials and other main roads during peak-hours and the congestions are expanding in intensity and duration due to the increase of car use. The mobility of people is seriously reduced, especially of the weak travellers (the poor, elderly, children, disabilities…). High level of noise and increasing air pollution from traffic overall the conurbation presented the negative impacts on urban environment. Moreover, the increase use of IMVs, especially private cars, are burning to the last drops of natural oil and invading the valuable urban space.

- **City Centre**

According to HAIDEP, the city centre of Hanoi is defined as the urban area within the second ringroad of Hanoi and including four districts (Hoan Kiem, Ba Dinh, Dong Da, Hai Ba Trung) (JICA and HAPC, 2006). The mixed urban forms, imbalance in road distribution, high density of activities (residents, jobs, services), incompletion of the first city ringroad, and poor traffic management are the main causes of the serious traffic congestion in the city centre all day long. Thus, the urban environment is seriously degraded. However, the severity of traffic accident is much lower than in the urban fringes and along the arterials.

- **Urban Arterials**

Five corridors are defined as major urban arterials, which continue the major National Highway (NH) into Hanoi centre, including Nguyen Trai-Tay Son-Nguyen Luong Bang (from Southwest- NH6), Xuan Thuy-Cau Giay-Kim Ma-Nguyen Thai Hoc (from West- NH32), Giai Phong-Le Duan (from South- NH1), Nguyen Van Cu- Cau Chuong Duong (from East – NH1A & NH5), Tran Duy Hung-Nguyen Chi Thanh (from Southwest-NH Lang Hoa Lac). The lack of road in Hanoi forces all types of vehicles to drive on the arterials, for example trucks, cars, buses, motorcycles, bicycles, and tricycles. Most of severe traffic accidents in the urban area have occurred along the arterials. Congestion is frequent and serious at intersections because the primitive two-phase signalized or non-signalised control. Levels of air pollution and noise extremely exceed the national standards for all day long.

- **Two-Wheeler Blocks**

This unique urban form prevents these blocks from four-wheelers, but the irregular road design, lack of traffic control, lighting are the main reasons of traffic accidents within the blocks and at the block's gates, where the alley meets the car-based roads. The high level of noise is also a big issue for the residents in these blocks. The connectivity of alleys is also an issue requiring solution. The other issue of safety in these blocks is the isolation in accessing to public services, for example, education, health and public transport.

7.3.2. Application of Traffic Management Strategies

- **Traffic Avoiding Strategy**

According to Chapter Six, Traffic Avoiding Strategy includes two basic traffic management measures, *Land Use Change* and *City Logistic.* As analysed in Chapters Five and Six, these two measures are applicable to overall conurbation and the city centre of Hanoi in a large scale and medium term project. The smaller scale and short-term application of Traffic Avoiding Strategy can be applied effectively for the two-wheeler blocks. Each block should be inserted with a mini-supermarket, a kindergarten, and a medical clinic. Each group of five to ten blocks should be provided with a primary school, a cinema, a playing ground, a central parking lot, and some public transport access points.

- **Traffic Shifting Strategy**

Traffic Shifting Strategy includes ten basic traffic management measures, which aim to shift travel demand from using IMVs to using public transport and NMT. The Supportive Measure, *Signalisation*, is recommended to improve applicability of the others. The complete Traffic Shifting Strategy can be applied to large urban areas, ***Conurbation*** and ***City Centre***, in which the later situations, ***Arterials*** and ***Two-Wheeler Block,*** are included. Some modified or reduced versions of Traffic Shifting Strategy can be applied for arterials (public transport focused shifting strategy) and for two-wheeler blocks (NMT focused shifting strategies).

- **Traffic Controlling Strategy**

Traffic Controlling Strategy includes five basic traffic management measures and it is considered as the most flexible traffic management strategy. This measure can be applied in all four situations and it is the major traffic strategy to be recommended for ***Arterials*** and ***Two-Wheeler Block***.

- **Integrated Traffic Management Strategy**

As discussed in Chapter Six, the integrated traffic management strategy in this study presents the technical contents of a Traffic Management Plan, which aims to influence urban transport system by all three area of impacts, avoiding, shifting and controlling. The complete version of this strategy is suitable to apply for overall ***Conurbation*** of Hanoi. Some reduced versions can be considered to apply for the ***City Centre***, for example, the exclusion of *Taxes and Duties* and *Registration Control* from the strategy package.

7.4. Application of Traffic Management Measures

7.4.1. Public Transport Measures

- **Public Transport Routing Improvement**

Applicability

This measure is highly applicable in Hanoi, in which the routing of public bus network needs to be adjusted frequently due to impacts of the rapid urbanisation, the changes of urban land uses, the implementation of infrastructure development projects and maintenance activities, and the implementation of development and improvement projects of public transport service.

In the period from 2006 to 2010, the completion of the first city ringroad improvement project will ask for the rerouting of all bus lines, which serve the transport demand on the corridor between northwest area and southeast area of the city conurbation. In addition, the completion of the third ringroad will attract all long-distance through traffic from the second ringroad, which will then offer more right of way for bus operation.

Responsible Institutions

For a city scale routing improvement project, TRAMOC is the main authority dealing with network planning, coordination of service, and providing new bus stops and stations. UTMB is the main authority that preserves the right of way for the routing improvements, including the roadways and area for new stops. TPB, UTI, and their subordinates are the main enforcers to ensure the right of way for public transport is protected orderly, especially during the first duration (one to two week) of the rerouting. As the main operator, TRANSERCO must be involved in any routing improvement activity.

- **Public Transport Scheduling Improvement**

Applicability

This measure is highly applicable to Hanoi bus system, in which the nigh time service has not been integrated between urban lines and between urban and regional services. Currently, Hanoi bus service is operating with high frequency during day time (from 5:00 to 19:00), but the night time service is running with relatively low frequency, from 2 to 3 buses per hour. Although no increase in frequency is required, an integrated schedule should be applied at the main bus interchanges (Gia Lam, Long Bien, Giap Bat, Ha Dong, My Dinh, Bo Ho, Ga Ha Noi, Cau Giay, Nam Thang Long) between urban lines and major regional lines during night-time (19:00 to 23:00). In addition, the service time of regional bus should be extended to 22:00 (instead of 19:00 currently) in order to serve the night-time transport demand. Therefore, this measure can be applied to overall urban bus network and seven regional bus corridors (between Hanoi and Bac Ninh, Vinh Phuc, Thai Nguyen, Ha Tay, Nam Ha, Hung Yen, Hai Duong).

Responsible Institutions

The most important authorities for implementing this measure are TRAMOC (urban bus service coordinator) and TIMB (regional road transport coordinator), while TRANSERCO is the major operator dealing with this measure in both urban and regional transport in Hanoi region. The service schedules of long-distance transport at Hanoi Railway Station and Noi Bai Airport should also be considered. Therefore, these two organisations should be included as secondary stakeholder (for information exchange). As a functional subordinate of HAPC, TUPWS is authorised to make the final decision for implementation of this measure.

- **Public Transport User Incentives**

Applicability

This measure is currently applied in Hanoi with financial incentive via a monthly ticket system, which divides the transport users into two categories: (i) priority frequent users (students, school pupils, workers) and (ii) ordinary frequent users. Prices of monthly ticket are differentiated. A single-line monthly ticket costs VND 25.000 and VND 50.000 for priority user and the ordinary one respectively. The multi-line tickets for these two groups are VND 50.000 and 80.000 VND. The non-incentive users are riding with flat rate ticket, which costs Vietnam Dong (VND) 3.000 for a single trip within the urban conurbation and 5000 for a trip between Noibai Airport and the city centre.

According to TRAMOC (2006), in the first half of 2006, the total transported passengers was 152,5 million, in which the incentive passenger volume was calculated for 121,8 million trips (80% of total passenger volume). The subsidy for incentive passengers was calculated for VND 146 billion (about 74,9% calculated cost for incentive passengers). The average subsidy per trip was about VND 1200 (about EUR cent 6). The figures prove that the financial incentive strongly encouraged Hanoians to travel by buses. Although the subsidy will increase accordingly with the fuel price, labour, and maintenance cost, this measure should be remained with some proper improvements in order to attract passengers and to reduce the average subsidy per trip.

Responsible Institutions

The main authority dealing with this measure is TRAMOC, which, under authority of HAPC, provides user incentives directly via selling monthly bus-passes and indirectly via a service contract with the line's operator, who wins the free bid for providing service.

The main technical function of TRAMOC is monitoring the service quality and initial auditing the monthly balance sheets. The final decision on certifying service quality is made by TUPWS's director and the balance sheets are finally auditing by DOF before issuing the payment of subsidy amount for the line's operator.

All changes of this measure need approvals of the chairman of HAPC (the city's mayor), except the changes related to ticket's prices (single trip ticket and monthly tickets). These prices are decided by a meeting of the ***People Council***.

- **Public Transport Information Service**

Applicability

Currently, public transport information service is provided separately by TRAMOC and TRANSERCO. TRAMOC provides only a simple bus map at the roofed bus stops, where the information board is available. The map provides only fixed-time information about the network routing and stops' location and it is selling to the passengers at a price of VND 15000. The same map is provided electronically on the website of TRANSERCO (www.transerco.com.vn) with a route finding function for users. The updated information about routing, service time, service frequency and fares are provided on the website. The updated information about rerouting, relocating of stops are also provided via public media (e.g. Hanoi TV, printed and online Newspapers). However, the information is rarely provided for weak travellers, including poor people, workers, elders, who normally have low accessibility to Internet and public media. The other issue is that no information about regional transport and paratransit is provided by both TRAMOC and TRANSERCO.

Responsible Institutions

An integrated public transport information service should be considered as the next step of improvement. As the coordinator of public transport service in Hanoi, TRAMOC should be the key institution to implement and operate the information service for public transport in Hanoi. The cooperation of TRANSERCO and other operators in providing information is also necessary.

- **Public Transport Management Centre**

Applicability

Hanoi Public Transport Management and Operation Centre (TRAMOC) was founded on 3rd September 1998 under decree number 3527/QD-UB of HAPC. Currently, the main function of TRAMOC is to coordinate and control quality of public transport services in the urban area of Hanoi. As the main authority in public transport, TRAMOC is authorised by TUPWS to invest new stops and stations for urban bus service. In implementing the user incentive measure, TRAMOC procures bus services of operators and sells them back to the frequent users (via monthly ticket system). In between 2006 and 2010, HAPC plans to privatise some parts of the TRANSERCO, including the bus service and long-distance bus stations. As planned, the first urban rail line will be operated in 2010 by a new operator. Accordingly, HAPC is planned to promote TRAMOC to be a so-called Hanoi Public Transport Authority, which will be a direct functional branch of HAPC, as similar to the position of TUPWS.

Responsible Institutions

In establishing the TRAMOC, TUPWS and public transport operators are the main responsible transport related institutions and HAPC is the main decision making body. In line with the new plan for Hanoi Public Transport Authority, HAPC is the responsible for preparation of plan, and the main decision making bodies are the City People Council and the Communist Party Committee.

7.4.2. Non-motorised Transport Measures

- **Sidewalks and Crossing Facilities**

Applicability

Except the alleys, all car-based urban roads in Hanoi have sidewalks, which are sufficient for walking only in terms of width, but not in terms of walking environment. The crossing facilities are lacking absolutely. Therefore, this measure is urgently needed to apply in overall urban roads. For the sidewalks, the first task is to provide a plan to connect the sidewalks and the alley network; secondly, to provide a plan for parking and/or business activities on the sidewalks; thirdly to stop cutting sidewalks for road expansion; finally to improve pavement surface of the sidewalk and to improve accessibility for wheelchairs. For the crossing facilities, the first task is to provide sufficient and accessible pedestrian zebras and warning signs at all intersections; secondly, to provide pedestrian bridges or tunnels for pedestrians along the urban arterials, especially in front of high demand generators that located between the first and second ringroad and on the second ringroad. This measure is integrated in the urban transport sub-sector plan of the Comprehensive Urban Development Programme in Hanoi Capital City (HAIDEP) (JICA and HAPC, 2006)

Responsible Institutions

The UTMB is the main responsible institution for operating and regulating of the roads and sidewalks. Therefore, this bureau should be responsible for planning of this measure. Currently, the UTI is the responsible institution for monitoring and enforcement of the sidewalks and TPB is responsible for controlling and enforcement of the carriageways, including all at-grade crossing facilities. In principle, the plan of this measure needs an approval of HAPC after being audited by the HUPA, HAPI, and DOF.

- **Non-motorised Transport Zone**

Applicability

In Hanoi, this measure can be widely applied for overall ancient quarter of the city and a section of Tran Hung Dao Street (between the main railway station and Friendship Culture Palace), and most of two-wheeler accessed only blocks within the second ringroad. This measure is currently applied along the Hang Dao- Hang Ngang Street in the ancient quarter, during night time (19:00 to 5:00). The main objective of this application is to establish a night market on this road.

Responsible Institutions

For the application in the ancient quarter and on Tran Hung Dao Street, UTMB is the most important institution for planning and operating this measure. In principle, the plan of this measure needs an approval of HAPC after being audited by the HUPA, DONRE, and DOF.

For the two-wheeler accessed only blocks, UTMB is responsible for planning, and the people committees of the wards, where the blocks are located, can also undertake this responsibility with the technical supports of UTMB. The district people committees are the main decision making institutions for this measure.

- **Non-motorised Transport Information Service**

Applicability

This measure is the most applicable and highly effective to be applied in Hanoi. The main task of this measure is to provide a map (in paper form and electronic), in which the alley networks are presented together with the urban road (with sidewalks) and public transport network. A plan for provision of traffic signs and guide boards for bicyclists and pedestrians overall city is also required.

Responsible Institutions

Based on the existing map of the bus network, TRAMOC and TRANSERCO can simply add the information of alley network and provided to the NMT and bus users by their current information channels. For planning and provision of traffic signs and guide boards for NMT users, UTMB is the key responsible institution.

7.4.3. Individual Motorised Vehicle Measures

- **Taxes and Duties for IMVs**

Applicability

This measure is currently applied in Vietnam by two systems (i) import taxes for vehicles and parts, and (ii) registration duty based on vehicle purchasing price. Both systems are imposed by uniform rates for all fifty-five provinces and five special cities (Hanoi, Hochiminh City, Hai Phong, Da Nang, Can Tho). The high rate of import tax is currently considered as the main measure to control the growth of vehicle ownership. However, the impact of current vehicle registration duty is very limited due to the low and uniform rate for both rural and urban areas. Therefore, a separate registration duty system for Hanoi is required in order to control the vehicle ownership of the people. A gradual registration fee system should be considered to apply in accordance with engine capacity and age.

Responsible Institutions

DOF and TUPWS are responsible institutions to study and plan for a new registration duty system in Hanoi. An approval of the city people council is required before submitting the plan to get an approval of the Prime Minister (article 9 and 20, law of organisation of the government in Vietnam), after getting through the auditing process of the Ministry of Transport and Ministry of Finance.

- **Vehicle Registration Control**

Applicability

Currently, this measure is uniformly applied throughout the country by limitation of engine capacity of the newly registered motorcycles. Individuals and organisations are not allowed to register big motorcycles, which have a total volume of effective cylinder(s) more than 150 cm3, for private and normal commercial transport. Two other schemes, registration quota (one motorcycle per person) and required parking contract for new registered private car, have been applied in Hanoi between 2004-2005. However, these schemes were removed by their low effectiveness and the opposition of the General Assembly, which finally banned these schemes under lobby pressures of vehicle manufacturers. The proposal for Hanoi is to apply a control system based on vehicle age and emission rate. The required parking contract for new private car should be applied again with a more sophisticated monitoring and control system. The registration quota scheme should also be applied again but throughout the country.

Responsible Institutions

Under the authority of HAPC, TUPWS and TPB are the main responsible institutions for planning this measure. The first approval of City People Council is the basis to bring the plan of this measure to the national government. After getting through the auditing process of five ministries: Transport, Industry, Resources and Environment, Public Security (Department of Traffic Police), and Ministry of Defence (Department of Autos and Motorised Vehicles), this plan will be submitted to the Prime Minister in order to get a final approval (article 48 and 49, road traffic law in Vietnam 2001).

7.4.4. Multimodal and Intermodal Transport Measures

- **Signalisation of Intersection Control**

Applicability

This measure is integrated in the urban transport sub-sector plan of the Comprehensive Urban Development Programme in Hanoi Capital City (HAIDEP). The city plans to provide traffic signal controls for all 600 signal required intersections in the period up to 2020. This also plans to include a new area traffic control centre for all intersections in the city conurbation and the closed circuit TV system for monitoring traffic condition at intersection. Until 2010, this plan aims to replace all local controllers at 160 current signalised intersections, to signalise 140 intersections, and renovate the traffic signal control centre with new technology (JICA and HAPC, 2006).

Responsible Institutions

In principle, the UTMB and TPB are the main responsible institutions for preparing a detail plan for signalisation of intersection control in Hanoi, but Hanoi Urban Transport Project Management Unit will be responsible for the construction and installation phase. As a part of HAIDEP, this measure is already approved of by the Prime Minister. Therefore, the detailed plan will need only an approval of the HAPC (article 37, road traffic law in Vietnam 2001) after the auditing process of the DOF and HAPI.

- **Traffic Calming and Speed Reduction**

Applicability

According to Article 7, Decree 42/2005/QD-BGTVT of the Minister of Transport, Hanoi and other cities in Vietnam apply a uniform speed reduction regime for motorised vehicles driving on the urban roads. Private cars, pickups, and vans are not allowed to drive faster than 50 kilometres per hour. Motorcycles, light trucks (up to 3,5 ton) and minibuses (between 10 to 29 seats) are not allowed to driver faster than 40 kilometres per hour, the other vehicles are not allowed to drive faster than 35 kilometres per hour (MOT Vietnam, 2005). However, the traffic-calming concept has not been applied. Therefore, a speed limit of 30 kilometres per hour can be applied for the ancient and French quarter. Moreover, the traffic-calming concept with a speed limit of 15 kilometres per hour should be applied in all two-wheeler accessed only blocks.

Responsible Institutions

The UTMB and TPB are the main responsible institutions in planning this measure. An approval of City People Council would be required before submitting the plan to the transport minister for getting the final decision (article 12, road traffic law in Vietnam 2001).

- **Urban Traffic Information**

Applicability

This measure is integrated in the urban transport sub-sector plan of the Comprehensive Urban Development Programme in Hanoi Capital City (HAIDEP). Up to 2010, the city plans to provide a typical radio information system for car drivers. A real-time route guidance system is planned to operate in 2016. The driver information system is planned to operate under the umbrella of the area traffic control centre (JICA and HAPC, 2006). In addition, a typical traffic information service (maps, traffic signs, guide boards, website) is necessary to provide information for motorcyclists and other road users. The public transport information service should also be integrated into the HAIDEP's plan.

Responsible Institutions

In principle, the UTMB and TPB are the main responsible institutions for preparing a detailed plan for urban traffic information service in Hanoi, but Hanoi Urban Transport Project Management Unit will be responsible for the construction and installation phase. As a part of HAIDEP, this measure is already approved of by the Prime Minister. Therefore, the detailed plan will only need an approval from the HAPC (article 37, road traffic law in Vietnam 2001) after the auditing process of the DOF and HAPI.

- **Land use change**

Applicability

Although no specific land use change for traffic management has been adopted so far in Hanoi, the HAIDEP proposed a strategic plan to redistribute urban population in Hanoi in order to reach a population density in the city centre about of 252 persons per square kilometre and a rate of 132 persons per square kilometre in the urban fringe districts in the year 2020. In the urban area, this plan requires an area of 100 square meter per capita, which includes 26 square meter for resident, 33 square meter for public facility, business and commerce, 67 square meter for industry and 16 square meter for green area. A specific short-term land use change for traffic management can be further developed in details under the above standards.

Responsible Institutions

The TUPWS (UTMB) and HUPA are the main responsible institutions to carry out the planning phase of this measure. The detail plans in urban blocks also needs the participation of the district people committee. An approval of the HAPC is necessary before the plan can be submitted to get the final decision of the city people committee.

7.4.5. Freight Transport Measures

- **City Logistic Management System**

Applicability

Although all manufacturers, shopping centres and households are applied or served by logistic, this service has never been mentioned in any official transport and land use plan in Hanoi. Therefore, the concept of centralised logistic management system should be introduced in Hanoi.

Responsible Institutions

The most important institutions to initiate this concept are Hanoi Railway Station, Noi Bai Airport Authority, Hanoi Post and Telecommunication Company and TRANSERCO. These four organisations are currently operating the biggest distribution facilities in Hanoi.

7.5. Conclusions

This chapter examined the existing urban transport conditions and proposed the application of traffic management strategies and measures in Hanoi, Vietnam.

- **Existing Urban and Transport Conditions in Hanoi**

Apart from the global factors, the urban conditions in Hanoi are addressed by three main points: (i) rapid urbanisation, (ii) high population density, and (iii) two-wheeler accessed only blocks. These conditions generate very high and compact transport demand for the whole city, require high transport capacity, but are under the high pressure of space limitation.

Transport conditions in Hanoi are firstly featured by rapid motorisation and extreme high motorcycle use. Secondly, the insufficient infrastructure and service capacity are addressed by (i) lack and imbalance distribution of road and parking facilities, (ii) low availability and incompetent public transport services, and (iii) less developed and ineffective traffic management.

The main issue of the city level political institutions is the overlapping between decision powers of City Communist Party, People Council and People Committee, which creates many disturbances and delays in executing the decisions. Hanoi Transport and Urban Works and Services (TUPWS) and Hanoi Traffic Police Bureau (TPB) are two major governmental authorities, which are directly related to transport sector. The main issue of transport authorities is lack of cooperation and coordination between TUPWS and TPB and between the bureaus within TUPWS. Hanoi Transport and Service Corporation (TRANSERCO) is the main public transport operator in the urban area. Between authorities and operators, the main issue is also the overlaps between functions, especially in planning and quality management.

The urban transport conditions are the main causes of traffic accidents, congestion, and degradation of urban environment in Hanoi.

- **Application of Traffic Management Strategies**

The urban transport conditions Hanoi are defined in four typical urban transport situations as follows: ***(i) Overall Conurbation, (ii) City Centre, (iii) Arterial,*** *and* ***(iv) Two-wheeler accessed only blocks***. In correspondence with these situations, applications of four typical traffic management strategies are examined as follows:

Traffic Avoiding Strategy is applicable to apply in ***Overall Conurbation*** and the ***City Centre*** of Hanoi in a large scale and medium term project. The smaller scale and short-term of this strategy can be applied effectively for the two-wheeler blocks.

Traffic Shifting Strategy can be applied for large urban areas, ***Conurbation*** and ***City Centre***, in which the later situations, ***Arterials*** and ***Two-Wheeler Block,*** are included.

Traffic Controlling Strategy can be applied to all the four situations and it is the major traffic strategy to be recommended for ***Arterials*** and ***Two-Wheeler Block***.

Integrated Traffic Management Strategy is suitable to apply to the ***Overall Conurbation*** of Hanoi. Reduced versions can be considered to apply for the ***City Centre***.

- **Application of Traffic Management Measures**

Table 7-1 draws a clear conclusion about scale, area of application and responsible institutions for each traffic management measure. In the scale of application, seven measures are fully applicable for all transport modes under a general strategy, in which the other eight measures are partly applicable. Eleven measures are fully applicable and two others are partly applicable under a modal strategic approach. Ten measures can be applied for a facility or service unit of certain transport mode. Regarding the area of application, except the *NMT Zone,* all measures are fully applicable to the ***Conurbation***. Twelve measures are fully applicable to the ***City Centre***, while only seven measures can be applied fully along the urban ***Arterials***, and six measures are fully applicable for the ***Two-wheeler Block***.

Table 7-1: Proposal for application of traffic management measures in Hanoi

No.	Measure	Strategic Approach			Area of Application				Responsible Institutions		
		General	*Modal*	*Unit*	*Con-urbation*	*City Centre*	*Arterial*	*Two-wheeler Block*	*Authorities*	*Operators*	*Political Institutions*
1	Public Transport Routing improvement	Y	X	X	X	X	X	Y	TRAMOC, UTMB, TPB, UTI	TRANSERCO	TUPWS
2	Public Transport Scheduling improvement	Y	X	X	X	X	X		TRAMOC	TRANSERCO	TUPWS
3	Public Transport users incentives	Y	X	X	X	X	Y		TRAMOC, DOF	TRANSERCO	HAPC,People Council
4	Public Transport Information Service	Y	X	X	X	X	X	Y	TRAMOC	TRANSERCO	*not required*
5	Public Transport Management Centre	Y	X		X				TUPWS	*not required*	HAPC, People Council, Party
6	Sidewalks and Crossing Facilities	Y	X	X	X	X	X	X	UTMB, UTI, TPB	*not required*	HAPC
7	Non-motorised Transport Zone	X	X	X		X		X	UTMB, UTI, TPB	*not required*	HAPC
8	NMT Traffic Information Service	Y	X	X	X	X	X	X	UTMB, TRAMOC	TRANSERCO	TUPWS
9	Vehicle Taxes and Duties for IMVs	X	X		X				TUPWS, DOF	*not required*	National Government
10	Vehicle Registration Control	Y	X		X				TUPWS, TPB	*not required*	HAPC, People Council
11	Signalisation of Intersection Control	X	Y	X	X	X	X		UTMB, TPB	UTPMU, TSCC	HAPC
12	Traffic Calming and Speed Reduction	X	Y	X	X	X	X	X	UTMB, TPB	*not required*	People Council
13	Urban Traffic Information Service	X			X	X	Y		UTMB, TPB	*not required*	HAPC
14	Land Use Change	X		X	X	X	Y	X	TUPWS, HUPA, DONRE	*not required*	HAPC, People Council
15	City Logistic Management System Improvement	X	X		X	X	Y	X	*not required*	TRANSERCO, HRS, NAA	*not required*

Note

PT: Public Transport, NMT: Non-motorised transport, IMV: Individual motorised vehicle,

X: Fully applicable, Y: Partly applicable, Blank cell: Not applicable

Party: Hanoi Communist Party Committee
People Council: Hanoi People Council
HAPC: Hanoi People Committee
HAPI: Hanoi Department of Planning and Investment
DONRE: Hanoi Department of Resources and Environement
DOF: Hanoi Department of Finance
HUPA: Hanoi Department of Urban Planning and Architechture
TPB: Hanoi Traffic Police Bureau
TSCC: Hanoi Traffic Signal Control Centre

TUPWS: Hanoi Transport and Urban Works and Services
UTMB: Urban Traffic Management Bureau
TRAMOC: Urban Public Transport Management and Operation Centre
UTI: Urban Transport Inspection
TRANSERCO: Hanoi Transport Corporation
UTPMU: Hanoi Urban Transport Project Managemengt Unit
HRS: Hanoi Railway Station Company
NAA: Noibai Airport Authority

In application of traffic management measures, Hanoi Transport and Urban Works and Services and its subordinate bureaus are the key authorities. In enforcing and controlling traffic signal, Hanoi traffic Police Bureau is the main responsible institution. In public transport, Hanoi Transport Corporation (TRANSERCO) is the most important operator in both passenger and freight transport. The key political decision-makers in Hanoi are Hanoi People Committee and Hanoi People Council. However, the most powerful body is the City Communist Party Committee.

8. Conclusions and Recommendations

8.1. Conclusions

8.1.1. Preliminary Backgrounds

This study began by providing an overview of urban transport situation of the cities in the South and Southeast Asia. The comparative data and analysis of this study have confirmed that such a sense of the motorcycle dependence was warranted. However, this study has also presented the situation with a much clearer image than what has been indicated in the literature on such motorcycle dependent cities.

Chapter One presented a number of motivations for this study, including (i) An Unique Situation of Urban Transport System, (ii) Urban Transport Problems and Opportunities, (iii) Relevance of Traffic Management for Motorcycle Dependent Cities, and (iv) Lack of Information and Research of Traffic Management in MDCs. These motivations have been substantially addressed by this dissertation as it has unfolded.

Six questions have guided and focused the study. The first asked for an examination on traffic management state-of-the-art. The second is about the definition of the unique situation, the-so-called motorcycle dependence, and the correspondent transport problems and causes. The third question demanded for a strategic policy framework for traffic management in Motorcycle Dependent Cities (MDCs). The fourth looked for possible traffic management measures for MDCs, and the fourth asked about the traffic management strategies. Finally, the study intended to propose possible application of traffic management in a typical MDC.

In this introductory chapter, the overall goal this study has addressed clearly is to find out a Traffic Management Concept that proactively alleviates the urban and transport problems and aims to develop a sustainable urban transport system in the Motorcycle Dependent Cities (MDCs). The subsequently objectives of this study are defined toward the answers to the research questions. The scope of the study was also bounded in the area of Traffic Management Concept and its contents. The focus in data collection is the general, large scale, citywide features of the transport and land use of some Asian cities.

The methodological approach of searching for traffic management solutions in MDCs of this study is substantially based on the German Transport Planning Process, in which three major phases are conducted in this study, including (i) pre-orientation, (ii) problem analysis, and (iii) searching for solutions. The proposal for application of traffic management solutions in a case study is established for the capital city of Vietnam, Hanoi.

Chapter Two reviewed the available literature in the developed countries on five fundamental aspects of traffic management: definitions, measures and strategies, planning of traffic management activities, and basic requirements for application.

- **Traffic Management**

The term *traffic management* is selected from different terminologies defining the efforts to balance demand and supply in transport system by a set of traffic management measures on three major strategic approaches: *to avoid traffic*, *to shift traffic* and *to control traffic*.

- **Traffic Management Measures and Strategies**

In the past, traffic management that was limited only in the area of traffic control and regulation of road traffic. Today, traffic management concept includes a wide range of measures, from the original traffic engineering to economical, administrative and organisational and information.

Application Level of Traffic Management Measures

The investigation shows that traffic management measures have been applied in most of developed countries, where the conventional traffic operation and control measures are fully developed and standardised. However, the dedicated measures are still implemented at level of pilot projects or by specific cases in most of countries, except in Germany, where the investigation proved that the urban and regional scales integrated traffic management programs have been implemented in most of German metropolitans.

Formulation of Traffic Management Strategies

Conventionally, *mutually supportive* was the key condition to combine different traffic management measures into a strategy. Later, this criterion has been interpreted into two types of benefits for combination of measures: (i) *combination for pursuing synergic effectiveness* and (ii) *combination for reducing implementation barriers*. Finally, the combination of measures and the correspondent transport situation should be presented in a standard formula, which was defined as the strategy mask.

- **Planning of Traffic Management Activities**

Traffic Management Package in Transport Development Plans

In many developed cities, this approach is popularly applied providing a very comprehensive plan, which covers all aspects of transport, including infrastructure, public transport, and management. The main issue is that the planners, decision makers, and implementers normally focus on infrastructure projects. Traffic management objectives are often ignored or not included in the priority lists.

Traffic Management Plan

In the USA, the travel reduction programs are recommended to apply a five-step planning process, but the scale of such programs is focused locally on the private employers. In Germany, practical and theoretical efforts focus on the approach of having a Traffic Management Plan in the urban transport planning system in order to fulfil the gap between long-term transport development plans and daily traffic management activities.

Assessment of Traffic management Measures and Strategies

The study on current literature found that the current approaches in assessing traffic management measures wildly apply multi-criteria assessment models, which allow assessing both quantitative and qualitative criteria simultaneously. The criteria to assess the measures are normally categorised into two groups:

- *Effectiveness* of measure including improvements of safety, mobility, economic efficiency, and environment.

- *Applicability* of measure, including the difficulty to acquire costs, technical systems, institutional participation and public acceptance.

In the general studies, qualitative assessment is widely applied in order to make recommendations on applicable measures or strategies for further specific studies. The evaluation of measures is usually conducted by rating methods.

- **Requirements for Traffic Management**

Planning and implementation of traffic management activities requires a set of basic conditions, including laws and regulations, technical resources, finance, institutional participation, and public acceptance.

8.1.2. Urban Transport Problem Analysis

The urban transport problem analysis is conducted by examining the urban and transport condition in six cities (Hanoi, Hochiminh City, Bangkok, Jakarta, New Delhi and Taipei), which have a high level of motorcycle ownership and use. The main sources of data are collected from prevailing publications, official statistics, and governmental documents. Some data are collected for the first time by a field survey in Hanoi.

- **Motorcycle Dependence**

The motorcycle dependence of city is defined by examining three groups of indicators: *vehicle ownership*, *availability of transport alternatives*, *use of motorcycle*. The results indicate that in a typical motorcycle dependent city the urban traffic is presented as follows:

- High motorcycle ownership, higher than 350 MCs/1000 inhabitants,
- Lack of public transport alternatives (less than 1 buses /1000 inhabitants) and incompetent NMT compared with the motorcycle,
- Very high share of motorcycle in the traffic flow (more than 50%)
- High modal split of motorcycle (more than 40%) and extremely low modal split of public transport (less than 20%) while the percentage of NMT trips is still significant (about 20 to 40%).

Among six selected Asian cities, the analyses proved that Hanoi and Hochiminh city are in the situation of *captive motorcycle dependent*.

- **Problems of the Urban Transport in MDCs**

Traffic Accident

Traffic accident is the most serious traffic problem of the MDCs in comparison with other types of city. Severe traffic accidents mainly occur outside the city centres, main arterials and on the ring road. In Hanoi, the severity of accidents is proportionally related to the growth of motorcycle ownership, while the data of Taipei shows a converse. Moreover, the comparative data shows that a city can achieve a safe traffic condition in the condition of high motorcycle use, as presented by the case of Taipei.

Traffic Congestion

Traffic congestion of a captive motorcycle dependent city (Hanoi) is currently not as serious as a traffic-saturated city (Bangkok). Traffic congestion in MDCs occurs during the peak periods, along the main urban arterials and at intersections and bottlenecks. The average travel speed during peak hour is reasonable, and the average travel time is relatively short, but congestion will increase quickly in the near future by increasing of car use.

Environmental Pollutions

Currently, transport is the most important source of air pollution in Hanoi and Hochiminh City, where the motorcycle fleet comprises mainly four-stroke engine vehicles. In contrast, the motorcycle use creates serious air pollution in New Delhi, Bangkok, and Jakarta, where number two-stroke engine motorcycles is dominant. Apart from air pollution, level of traffic noise in both day- and nigh-time is serious overall transport network in the MDCs.

- **Urban Transport Issues**

Travel Demand and Behaviours

The travel demand in MDCs is extremely high due to high population density and high availability of motorcycle. Immaturity of road users in response to the motorisation, lack of traffic operation and control measures, weak enforcements are addressed as the main causes of traffic accidents in MDCs.

Road Infrastructure

Lacks of road and parking facilities are presented in the image of urban transport infrastructure in MDCs. Absence of road hierarchy in transport planning concept, insufficient finance and land for roads and parking facilities, no consideration of motorcycles and NMT are the manifestations of incomprehensive planning process and incapability in implementation.

Traffic Management

The study found that traffic management measures are planned and implemented accidentally, either from some demonstration projects, or by reactions of traffic police and transport authorities. The work of daily traffic management in MDCs is still done mainly by the conventional and primitive traffic operation and control measures.

Transport Planning and Implementation

The issues in transport planning and implementation in the MDCs are addressed as follows: (i) foreigner dependent planning, (ii) ambitious planning goals, (iii) lack of proper planning tools, (iv) lack of financial and human resources, and (v) lack of legal basis and institutional capability. The most critical issue in transport planning in MDCs is a lack of a proper strategic policy framework.

- **Urban Development Issues**

Politic and Socio-economic

The political environment is peaceful and not raising critical effect on urban transport. The economic growth of the countries and cities are impressive and continuing for decades. The economic success is the main cause of travel demand explosion in MDCs.

Demography and Land Use Condition

The MDCs are rapid urbanising in both population and area. The urbanisation is shown by two contradicted faces. On one side, the high density and mix land use will continue to be the pattern of the city centre and overall conurbation. On the other side, the low density and single land use will be the pattern of the new urban fringes.

Urban form

Most of MDCs have a monocentric urban form, in which urban activities are highly concentrated in the city centre. The urbanisation is processing outward from the centre following the oil-stain model. Apart from the explosion of motorcycle use, the incomprehensive urban planning concept and lack of land use control are the main reasons for the existence of many two-wheeler accessed only blocks in the MDCs.

- **Opportunities and Challenges**

Opportunities

The awareness of interdependencies between developed and developing countries encourages the quantity and quality of technical assistance from developed countries to developing countries.

The global information exchanges will allow the MDCs to learn from international failures and successes in urban transport development and management and to access the sophisticated planning tools and know-now, including the opportunities to develop their own human resources and technical tools that fit into the unique situation of the MDCs.

The constraints of finance and urban land will force the governments and investors to search for least cost solutions, which encourage the application of management measures. Moreover, the modularity and flexibility of traffic management measures allow them to work well in the functional fragmentation of the urban transport institutions.

The rapid urbanisation is challenging long-term forecasting solutions, and then requires the shorter term and more flexible solutions as traffic management measures.

The high-density population and mixed land use conurbation in MDCs are suitable conditions for a low cost sustainable urban transport system, including public transport and non-motorized transport services, and motorcycles.

Challenges

The explosion of car use and lacks of financial and resources for providing roads and mass transits are bringing the MDCs to the situation of traffic saturate cities, in which traffic chaos and pollution would be the key challenges. In addition, the car use explosion will make the society more dependent on oil, which will be finished very soon.

The sprawled urbanisation will make the distances of the essential daily trips become longer and encourage people to use the individual motorised transport modes for their daily travel. Consequently, the increase of transport costs in finance and time will reduce the economic attractiveness of MDCs.

Foreign assistance and technology transfer from a developed city will allow the foreigner dependent planning concepts to continue to exist.

The increasing social gaps, especially income and information, will prolong the situation of setting ambitious planning goals.

8.1.3. A Strategic Policy Framework for Traffic Management in MDCs

The Strategic Policy Framework is essential for all transport development and operation in the MDCs, including for planning and implementation of traffic management activities.

- **A Vision for Future of City**

The Strategic Policy Framework can start with a long-term vision for future development of the urban area, which presents the image of a liveable city, that is human oriented and environmental friendly, economically viable and efficient, and socially compatible. There is no doubt about that the MDCs are also looking on that vision.

- **The Strategic Goals**

A liveable city is served by a sustainable urban transport system defined by four major characteristics: mobility, safety, and environmental friendly and economic efficiency. These characteristics are then defined as four major goals of an urban transport system.

- **The Strategic Objectives**

The goals are sub-divided into more specific and measurable objectives, which are later considered as technical achievement for transport development and management activities in the urban areas. The criteria to measure these objectives are also defined, for example rate of accidents per one hundred persons is defined for measuring frequency of traffic accident at a specific location or overall urban area.

- **The Development Scenario**

The next step discusses a suitable development scenario for future urban transport system in MDCs. From the reviewed literature, one can see very great advantages of the transit city in comparison with the others. Therefore, this model of urban transport and land use is recommended for MDCs. The development path to a transit city is also defined and, before getting to the end, the modern bus city is recommended to be at the midway.

- **The Modal Objectives of Traffic Management**

The modal objectives are defined as: *public transport prioritisation*, *non-motorised transport promotion*, *individual motorised transport reduction*, *intermodal and multimodal transport improvement*, and *freight transport improvement*. These modal objectives open gates for traffic management strategies and measures to contribute on achievement of the strategic vision, goals and objectives.

- **Implementation Objectives of Traffic Management**

Finally, the expectation from a traffic management solution is defined by two criteria: *effectiveness* and *applicability*. The effectiveness will be measured by strategic objectives of urban transport system, and applicability is indicated by the fulfilment of what is defined as basic requirements for traffic management.

8.1.4. Traffic Management Measures for Motorcycle Dependent Cities

This chapter firstly established a multi-criteria assessment model to assess and select the most suitable traffic management measures to recommend for the MDCs. Secondly, it conducted the assessment process for thirty-four candidates and finally classified these measures into four priority groups.

- **Assessment Model**

A multi-criteria assessment model is applied to assess the candidate measures and to recommend the most suitable measures for MDCs. In this model, two major criteria, namely *effectiveness* and *applicability* of candidate measures, are assessed based on strategic goals of traffic management and basic barriers for implementing traffic management activities.

Two AHP structures are established to represent two sub-models, *effectiveness* and *applicability*. A survey questionnaire among three groups of transport experts was conducted to obtain the weight of criteria and sub-criteria of the two sub-models. AHP-based software, EXPERT CHOICE (version 11.0), was employed to analyse the consistent ratio of the answers and to obtain the weights.

In terms of effectiveness, the traffic safety was rated as the most expected improvement of urban transport in the MDCs (32% weight). The followings are mobility (27%), environment and resources (21%), and economy (20%). In term of applicability, public acceptance has been rated the most difficult barrier (28%). The following are institutional participation (26%), cost of measure (25%) and technical systems (21%).

The next step is to evaluate the measures based on the results of the estimations. The priority in recommendation of traffic management measures for MDCs are selected according to the following terms:

- The first priority group consists of measures that have a *High level of Effectiveness* and a *Low level of Difficulty*.
- The second priority group consists of measures that have **either** a *High level of Effectiveness* and *a Medium level of Difficulty*, **or** a *Medium level of Effectiveness* and a *Low level of Difficulty*.
- The third priority group consists of measures that have a *Medium Level of Effectiveness* and *Medium Level of Difficulty*.
- The fourth priority group consists of other measures.

- **Assessment of Traffic Management Measures**

Fifteen traffic management measures have been selected to be in the first priority group, which includes five public transport measures, three NMT measures, two individual vehicle measures, four multimodal and intermodal transport measures and one freight transport measures. The other nineteen measures are assigned in the second (14 measures), third (2 measures) and fourth (3 measures) priority group.

In a general view, the first priority group combines a good mix of measures, which represent traffic management activities in all transport forms and modes. Although levels of impacts may be varied according to specific conditions of cities, each measure of the list is highly recommended to be applied to every MDC and to other developed and developing cities. With an objectives-led approach in Traffic Management Planning, the measures in the first priority group are recommended to be the Basic Measures of traffic management strategies.

The final emphasis is that, the implementation of any traffic management measure needs sufficient protection of traffic laws, effective, and promptly enforcement service, and good awareness of all stakeholders. Although improvements of traffic laws, enforcement service and traffic education were not studied in this chapter as traffic management measures, they are always considered as the fundamental requirements for traffic management in particular and urban transport development in general in all MDCs.

8.1.5. Traffic Management Strategies in MDCs

- **The Strategy Formulation Model**

The first step aims to select the most suitable ***Basic Measures***, whose implementation brings the major effort for solving the urban transport problems. The second step is to define the ***Supportive Measures***, which aim to improve applicability or to reduce level of difficulty in implementation of the Basic Measures. In many cases, conflicts cannot be solved by traffic management measures, thus requiring additional non-traffic management measures, called ***Conflict-Solving Measures***.

- **The Traffic Avoiding Strategy**

This strategy in MDCs consists of two traffic management measures, *Land Use Change* and *City Logistic*, which are defined as the Basic Measures of the strategy. Additional measures in the field of human and business resettlement are required to ensure that the dis-benefits by relocating of residential and business places would be compensated equally.

- **The Traffic Shifting Strategy**

This strategy includes desirably ten Basic Measures, which are five public transport measures (*PT Routing, PT Scheduling, PT User Incentives, PT Information, Management Centre*), three NMT measures (*Pedestrian Facilities, NMT Zone, NMT Information*), and two IMV measures (*Taxes and Duties, Registration Control*). In assessing the capability of Supportive Measure, *Signalisation* is selected to provide all required intersection operation and control systems.

- **The Traffic Controlling Strategy**

This strategy includes desirably five Basic Measures, which are one non-motorised transport measure (*Pedestrian Facilities*), one measure for individual motorised vehicles (*Registration Control*), and three multimodal measures (*Signalisation, Traffic Calming, Traffic Information*).

- **The Integrated Traffic Management Strategy**

This strategy includes seventeen traffic management measures. Fifteen Basic Measures are expected to influence urban transport system by: avoiding traffic, shifting traffic, and controlling traffic. The inclusion of other two economic measures, *Road Pricing and Parking Pricing*, as financial Supportive Measures for the strategy, was recommended. The assessment also proved that no considerable conflict was raised by the inclusion of these two measures. Specific legal improvements and political lobby would be required in order to over come such difficulties in getting institutional participation and public acceptance.

8.1.6. Proposal for Application in Hanoi

- **Application of Traffic Management Strategies**

The urban transport conditions Hanoi are defined in four typical situations as ***(i) Overall Conurbation, (ii) City Centre, (iii) Arterial,*** *and* ***(iv) Two-wheeler accessed only blocks***. The applications of typical strategies are proposed in accordance with these situations.

Traffic Avoiding Strategy is applicable to apply to the ***Overall Conurbation*** and the ***City Centre*** of Hanoi in a large scale and medium term project. The smaller scale and short-term of this strategy can be applied effectively to the two-wheeler blocks.

Traffic Shifting Strategy can be applied to large urban areas, ***Conurbation*** and ***City Centre***, in which the later situations, ***Arterials*** and ***Two-Wheeler Block,*** are included.

Traffic Controlling Strategy can be applied in all the four situations and it is the major traffic strategy to be recommended for ***Arterials*** and ***Two-Wheeler Block***.

Integrated Traffic Management Strategy is suitable to apply to the ***Overall Conurbation*** of Hanoi. Reduced versions can be considered to apply to the ***City Centre***.

- **Application of Traffic Management Measures**

Table 7-1 draws a proposal of application of the first priority measures in the Hanoi. Regarding the application scale, seven measures are fully applicable for all transport modes under a general strategy, eleven measures are fully applicable, and ten measures can be applied for a facility or service unit of certain transport mode.

Regarding the area of application, except the *NMT Zone,* all measures are fully applicable for the ***Conurbation***. Twelve measures are fully applicable for the ***City Centre***, while only seven measures can be applied fully along the urban ***Arterials***, and six measures are fully applicable for the ***Two-wheeler Block***.

In implementing traffic management measures, Hanoi Transport and Urban Works and Services and its subordinate bureaus are the key authorities for planning, provision and operation of the measures. With regard to enforcement and control of traffic signal, Hanoi traffic Police Bureau is the key responsible institution. In public transport, Hanoi Transport Corporation (TRANSERCO) is the most important operator in both passenger and freight transport. The key political decision-makers in Hanoi are Hanoi People Committee and Hanoi People Council. However, the most powerful body is the City Communist Party Committee.

8.2. Remarks on Significance and Limitations of the Results

- **Significance of the results**

Firstly, this study collected systematically a set of definitions, which related to traffic management, including the terms of traffic management, measure, strategy, and plan.

It also compared and found the differences in the level of application and in the planning approach of traffic management in the USA, United Kingdom and Germany. It concluded for the first time that the German approach in planning traffic management activities is the most suitable approach for the fast developing cities, including the MDCs.

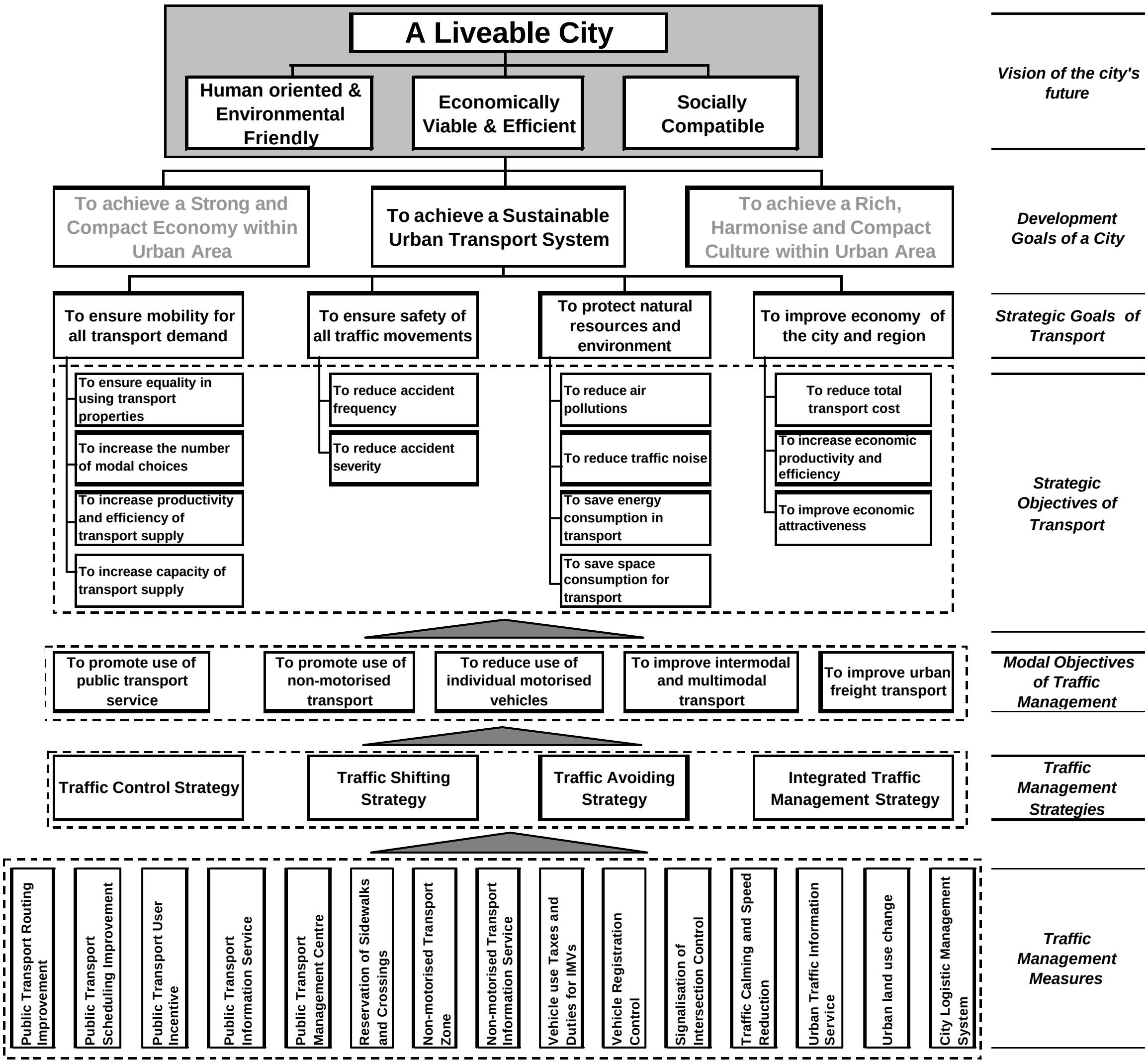


Figure 8-1: The traffic management concept for motorcycle dependent cities

In analysing transport situations in the MDCs, the definition ***motorcycle dependence*** has been developed for the first time based on three groups of indicators. Although more study effort is required, this term can be used for further research and publications as the key criterion to define and categorise Motorcycle Dependent Cities.

Although most of the data were collected from secondary sources, the transport problems and causes have been examined comparatively for the first time to define current situations and future trends of urban transport system in the selected MDCs. This study also concluded that the ***two-wheeler accessed only block*** is unique and this form of urban residential area will continue to present in the conurbation of the MDCs.

As the main purpose of this study, a Comprehensive Traffic Management Concept has been established for Motorcycle Dependent Cities. This concept starts with a Strategic Policy Framework, in which a hierarchy of vision, goals, and objectives have been completely formulated.

The strategic approaches are established and applicable measures are recommended as the means and tools to achieve the objectives, goals and the final vision. Although this concept has been established qualitatively and from a general perspective, it is applicable for both theoretical and practical study on traffic management in Motorcycle Dependent Cities and other types of City in the developing world (see Figure 8-1 above).

The establishments of measure assessment model and strategy formulation model can also be considered as a contribution. The categorisation of assessment criteria into two groups, effectiveness and applicability, is a new alternative to the conventional cost-benefit or total cost assessment model. The principles of integrating measures into strategy package, for synergic effectiveness and for reducing the barriers in implementation, are applied for the first time to formulate traffic management strategies.

- **Difficulties and Limitations of the results**

The main difficulties of this study are the large scale of research problems and lack of available data and computerised tools. The area of research problems is a broad traffic management concept, in which many subsidiaries must be touched, for example measure, strategy, planning process, assessment mode, formulation model, and etc. The valid data about transport conditions in motorcycle dependent cities is hardly to collect. Qualified literature on traffic management in these cities is very limited and hard to access. So far, no computerised tools for motorcycle dominated traffic flow have been developed.

The difficulties are the main reasons for the limitations of the study's results. The first is the existence of some gaps in comparative data. The second and most important is the qualitative assessment approach. Due to a lack of qualified literature regarding assessment of traffic management measures in MDCs, the quantitative assessment based on literature review cannot be conducted. Under the framework of a doctoral dissertation, it is impossible to provide quantitative assessment of traffic management measures and strategies without proper computerised tools. Therefore, further studies are needed to confirm the results of this study by quantitative evidence.

8.3. Recommendations

- **General Recommendations**

For application of Traffic Management or any other transport development measures in Motorcycle Dependent Cities and other developing cities the following recommendations should be considered by both researchers and implementers:

- To reduce level of foreigner dependence in transport planning by developing proper planning guidelines, technical standards, computerised tools and personnel skills.

- To encourage public participation in urban and transport development planning process in order to avoid ambitious planning goals and corruptions.
- To include legally the Traffic Management Plan as a separate type of plan in the urban transport planning system.

- **Recommendations for Hanoi**

Apart from the general recommendations, the application of traffic management in Hanoi should specifically consider the following points:

- To define a clear legal basis and responsibilities of different transport related institutions and political decision-making bodies.
- To integrate the annual Transport Operation Plan of the Transport and Urban Work and Services and the annual Traffic Control and Enforcement Plan of the Traffic Police Bureau and the Public Transport Operation Plan of the Urban Public Transport Management Centre into one Traffic Management Plan. A study is required to provide a clear concept for this integration.
- Traffic Management should be considered as the key transport approach in solving transport problems in the conurbation, the city centre, and the two-wheeler accessed only blocks of Hanoi. The infrastructure development approach should be considered as the requirements for application of traffic management solutions.

- **Suggestions for Further Research**

Regarding the development of a comprehensive definition of motorcycle dependent city, further quantitative studies on transport and land use interactions are required.

In order to promote traffic management application in Motorcycle Dependent Cities, the following important studies are needed:

- Quantitative application of the assessment model for specific measures in a typical Motorcycle Dependent City (e.g. Hanoi, Hochiminh City).
- Quantitative application of the strategy formulation model for specific strategies in the Motorcycle Dependent Cities (e.g. Hanoi, Hochiminh City)
- A comprehensive study on application of Traffic Management Plan in Motorcycle Dependent Cities.

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